SMALL OSCILLATOR DOES BANG-UP JOB ON 2 METER BAND

Grid-Stabilized Circuit Uses RCA-815 Tube

By J. H. OWENS, W3ASZ/2

The revival of Ham Radio via a temporary allocation at 2½ meters put most of the uhf boys back in business and gave many of the low-frequency fellows their first taste of vhf work. But the venture was short lived, as the band was quickly shifted down to 2 meters.

Then, a great many Amateurs found that it's a long way from 116 Mc to 144 Mc. Mediocre 2½-meter design techniques did not work well on 2 meters. Likewise, many tubes that performed excellently on the lower frequency band were found to be little better than crutches at 144 Mc. An exception to this is the RCA-815 dual beam power tube. It is the purpose of this article to show how easy it is to use this tube in a nifty little oscillator-transmitter that will bring in complimentary reports consistently.

Furthermore, the circuit is not sensitive to minor changes in mechanical design—if the fundamentals are observed, the RCA-815 will perform nicely in a wide variety of arrangements.

Grid Circuit Important

The primary factor that makes possible the excellent performance of this transmitter is the design of the grid circuit. In a TPTG oscillator, it is the duty of the grid tank to see that the grids receive ample driving power with low losses, and to assert a definite controlling effect upon the frequency of oscillation. These properties are fairly simple to build into low-frequency oscillators, but at 144 Mc, obtaining them can be very difficult because of such factors as, (1) the input resistance of a tube is low enough to load down the grid tank, and (2) the input capacitance of a tube is high enough to resonate a couple of inches of wire to a frequency lower than 144 Mc.

The solution to the problem turned out to be rather simple and straight-forward, once the problem

"HAM TIPS" ANNOUNCES CONTEST FOR RCA TUBE EQUIPPED RIGS

Scheduled for each issue of HAM TIPS is a photograph and description of an outstanding Ham rig that is 100% RCA tube equipped. Send your photos, name, and Amateur call letters to the Editor of HAM TIPS, RCA Tube Department, Harrison, New Jersey. If you win, you will receive a check for $10.00, and your rig will be pictured in a forthcoming issue. All entry material becomes the property of RCA, and cannot be returned.

W2BFB WINS THE OPENING PRIZE
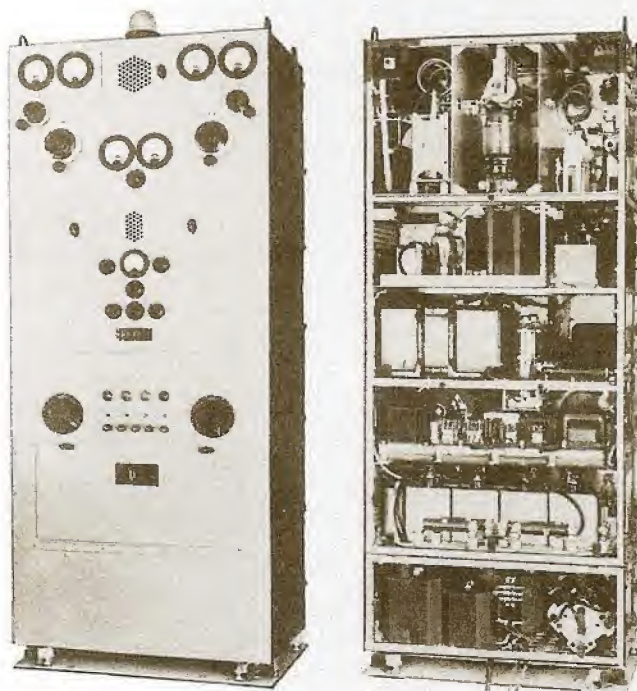
Congratulations and ten bucks go to James N. Whitaker, 93 Shepard Avenue, Englewood, New Jersey for the above photographs.

The front-panel picture is very professional, but the rear view proves that Jim Whitaker is a regular cramming, jamming, space-conserving, ingenious Ham.

The final amplifier uses a pair of RCA 833-A's, driven by an RCA 4E27/8001 and modulated by a pair of RCA 810's. Power is furnished by four RCA 872A's in a bridge circuit. Jim, who is engineer in charge of Transmitter Division, Hammar-lund Manufacturing Company, states "The 833A's will take 2500 watts input at 28 Mcs with a plate circuit efficiency of more than 82%."

Too bad he can't use that power on the air!

RF CHOKE FORMULA HELPS MAKE COIL FABRICATION EASY

Choke "Know How" Valuable in Rig Construction

By J. G. BEARD
RCA Engineering Products Dept.

Many amateurs who are building new transmitters or receivers for use on the vhf bands will need rf chokes. The best rf choke is one that has the greatest amount of reactance for a given value of resistance. This requirement can be met by the use of a length of wire equal to one quarter of the operating wave length.

The wire should be wound on a small mandrel of less than ½" diameter, and the mandrel should then be removed. The coil should be stretched a little so that adjacent turns do not touch. Use of #18 or larger wire will make the coil self-supporting and rigid.

Formula Applications

The following table gives the correct length of wire for operation in the bands shown.

Freq. Band	Length of Wire
50 Mc— 54 Mc	56.6 inches
144 Mc—148 Mc	20 "
235 Mc—240 Mc	12.5 "

For other bands the required length of wire in inches can be determined by dividing 2953 by the frequency in megacycles. As long as the diameter of the choke coil is kept small, the formula gives a length of wire which is quite accurate.

Choke coils should be positioned in the apparatus so that they do not couple to each other or to tank circuits. They should also be mounted at right angles to the chassis, because mounting them parallel with the chassis has the undesirable effect of increasing their distributed capacitance. Hot and cold end connections should be kept as short as possible.

Quarter-wave chokes, for most effective operation, should have their "cold" ends by-passed with mica or air-dialectric capacitors having short leads. Coils made and utilized in accordance with these design specifications are very efficient in choking off RF.

EASY-TO-BUILD TRANSMITTER
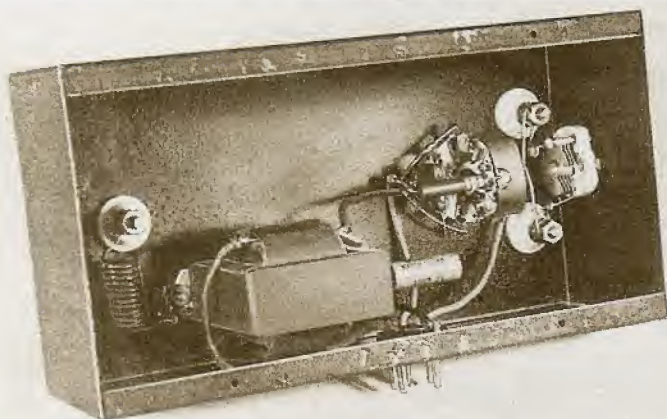
Bottom view photograph of Simple Oscillator, showing RF at one end and AF at the other, with plenty of space for meters and jacks.

SMALL OSCILLATOR

(Continued from Page 1, Column 1)

had been fully subjected to good reasoning. On a step-by-step basis, the answers popped up, as follows: (1) Rather than rely on or add to the tube's small grid-plate capacitance for feedback, it was decided to "over-neutralize" this small value of residual grid-plate capacitance.

Over-neutralization, accomplished by adding external capacitance from #1 plate to the #2 grid circuit, and external capacitance from #2 plate to the #1 grid circuit, provides better phase relationship between the rf currents in the grid and plate circuits than does the normal feedback path across the tube's grid-plate capacitance. (2) In order to give the grid some control over frequency, it is necessary to put a great deal of energy into the grid tank. This is done by using a large amount of "over-neutralizing" capacitance—far more than is necessary to sustain oscillations. With a low-loss grid tank, this design costs practically nothing. Because there is so much energy in the grid tank, the rf voltage is high, and the grids can be tapped far down to a low-impedance point where they will exert only a small loading effect. This permits good Q, and an appreciable control over the frequency of operation. The end result is improved frequency stability.

Design Factors

The grid tank starts with a piece of copper strap, ½ inch wide and 3 inches long, soldered directly to the grid terminals of the tube socket. The next section of the grid tank consists of two 3-inch pieces of #14 wire criss-crossed and connected between the socket grid terminals and the feed-through insulators. A five-plate midget condenser is connected across the feed-through insulators at this point.

The feed-through insulators are the next section of the grid tank. On top of the chassis is the remainder of the grid tank which consists of two feed-back plates, ½ inch wide and 2 inches long, soldered to 2-inch pieces of #12 wire which are in turn mounted on the feed-through insulators.

The second design factor responsible for the overall simplicity and performance of this rig is the plate tank circuit. There, a strap has been used in place of the usual rods. The advantages are several, e.g., (1) the surface area of a ½"-strap is greater than that of the popular ¼"-copper tubing, and (2) the copper straps are trimmed down to a width of ¼" at their ends and soldered directly to the plate clips, eliminating the losses usually suffered in flexible leads at this point, and (3) the shorting bar and the variable resistance it inserts in the rf circuit is eliminated.

Tuning Is Simple

Tuning of the linear plate tank circuit is accomplished merely by varying the spacing between the elements. When the straps are farthest apart, their inductance is highest, but when they are spaced closely, their inductance goes down. Tuning is therefore a very simple process—squeeze or spread the straps and the frequency goes up and down. It's as easy as that. To prevent any strain being transferred to the tubes' plate caps when the tank is tuned, the two sections are supported by a pillar-type ceramic stand-off insulator at a point 1¼ inches from the open end.

The modulation transformer is novel, though perhaps not an original idea. Use is made of a universal output transformer of the open-mounting type. It is first disassembled, and the core separated into its "E" and "I" sections. The transformer is then reassembled, but the "I" section is spaced from

PRICES DOWN AND RATINGS UP ON POPULAR HAM TYPE RCA-813

Production Savings on Other Tubes Passed on to Amateur

The popularity of the RCA-813 promises to skyrocket to new heights as a result of a new low price of $14.50 and the assignment to it of ICAS ratings. In Class C telephony, it will now take 200 ma plate current at 2000 volts, and in Class C telegraphy it will take 220 ma at 2250 volts. Two 813's will take 440 ma—virtually a kilowatt for $29.00.

Other factors that have contributed to Amateur acceptance of the 813 are (1) full input to 30 megacycles, (2) operation without neutralization from "Ten" to "Seventy-Five," (3) low driving power, and (4) good linearity with simultaneous modulation of the plate and screen. Here is the answer to your requirements for a high power final. More details of this in the next issue of HAM TIPS.

"Know-How" Lowers Tube Costs

Quite a few Amateur types have gotten a break in an RCA tube general price revision which was recently authorized by the OPA. Although the trend is upward, wartime mass production methods have provided a cost reduction in some cases, and this saving is passed on to our friends, the Hams. In the following listing, note particularly the 826, 829-B, 832-A, 833-A and the 8025-A.

Type	Amateur Net Old Price	New Price
2C43	$10.25	$9.50
5R4-GY	1.00	1.29
6F4	5.10	5.48
6J4	4.50	4.84
805	11.00	9.00
807	1.95	2.30
809	2.50	3.50
810	13.50	12.50
813	18.00	14.50
815	4.50	6.25
816	1.00	1.25
826	12.00	9.25
829-B	17.00	14.75
832-A	13.00	10.47
8025-A	11.00	9.25

HAM TIPS SERVICE FOR RIG QUERIES

That "brain twister" which every Amateur runs into at one time or other can now be submitted for solution to HAM TIPS' new question and answer service. Problems of general interest will be published in a monthly column to be conducted by Captain John L. Reinartz, USNR, back with RCA after seven years of military duty.

Well known to Hamdom for his long participation in amateur radio activities, his accomplishments include the design of the Reinartz receiver, the technical work "Reflection of Short Waves," published in 1925, and his communications work with the Byrd Arctic Expedition.

Readers are encouraged to send in problems concerning tubes and their application to RCA's Commercial Engineering Section, Harrison, New Jersey, which will act as a clearing house between Captain Reinartz and the editors of HAM TIPS. Each inquiry—whether it is published or not—will receive the attention of RCA engineering experts.
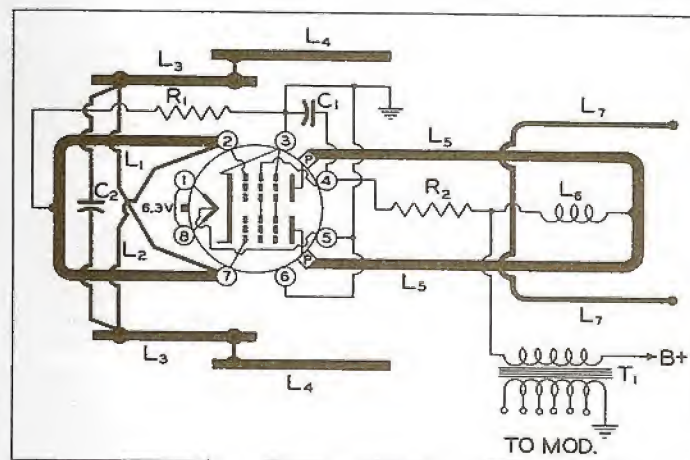
Schematic Diagram.

RCA-807 IS "LITTLE MAGICIAN" TO HAMS USING VERSATILE TUBE

Conceived and developed by RCA engineers, the 807 was announced to the world away back in 1936. Now ten years old, the 807 is still the most popular type in its class. At the recent Framingham Ham Fest, a survey was conducted, which revealed that the tube has even wider acceptance than we suspected—it was found to be the most popular type for final-amplifier use, by a substantial margin over the nearest competing type, which incidentally was also of RCA origin.

The 807's versatility is probably the biggest single contributing factor to its popularity. It is an excellent crystal oscillator and electron-coupled oscillator; it is unparalled for frequency doubler and tripler service; it will operate as a "straight-through" amplifier without neutralization, and it can be amplitude-modulated as easily as a triode—by simply connecting the screen dropping resistor to the modulation transformer together with the plate lead.

The high power-sensitivity of the 807, which is one of its desirable features, makes it require more careful handling than a low-gain triode. The plate and grid circuits must be fully isolated from one another, and an external shield should be used which extends up to the bottom of the plate element. In addition, a 0.005 μf mica capacitor should be installed directly on the tube socket terminals between screen-grid and cathode. One side of the filament should be grounded, and the other side should be by-passed to the chassis right at the socket, or in case a center-tapped filament transformer is used, both of the filament terminals should be by-passed at the socket to the chassis with 0.005 μf mica capacitors. If these few precautions are taken, no erratic behavior need be anticipated.

No wonder it is called the "Little Magician."

RCA - 807

THREE NEW TUBES JOIN RCA FAMILY

The 2BP1 and 2BP11 are the latest additions to RCA's line of cathode ray tubes. Both are 2-inch tubes, and are alike except for the character of their screens. The 2BP1 produces green fluorescence with medium persistence, and the 2BP11 gives bluish fluorescence with short persistence.

Compared with older types such as the 902A and 2AP1-A, the new tubes feature higher deflection sensitivity, sharper and more uniform focus, better contrast, greater light output, less current drain, and a separate base-pin connection for each electrode. With slight circuit modifications, they can be used in equipment built around the earlier types.

The 2BP1 was designed especially for direct viewing service in oscillographs, modulation monitors, and other visual indicators. The 2BP11, with its highly actinic trace, is intended primarily for photographic work.

The Amateur Net price for the 2BP1 is $8.75; for the 2BP11 it is $10.00.

A Triode for 2 Meters

The RCA-6C24 is a new external anode power triode that will interest progressive Amateurs who contemplate putting high power on the 6- and 2-meter bands. In Class C telephony service it will take a kilowatt at 148 megacycles.

Designed especially for FM and television, the 6C24 has low inter-electrode capacitances, low lead inductance, center-tapped filament, small size, and efficient copper radiator for forced-air cooling. The price is $45.00 net to the Amateur.

For further information on these and other RCA tubes, see your nearest RCA power tube distributor or write to the RCA Commercial Engineering Section, Harrison, N. J.

SCALED LAYOUT—TOP OF CHASSIS
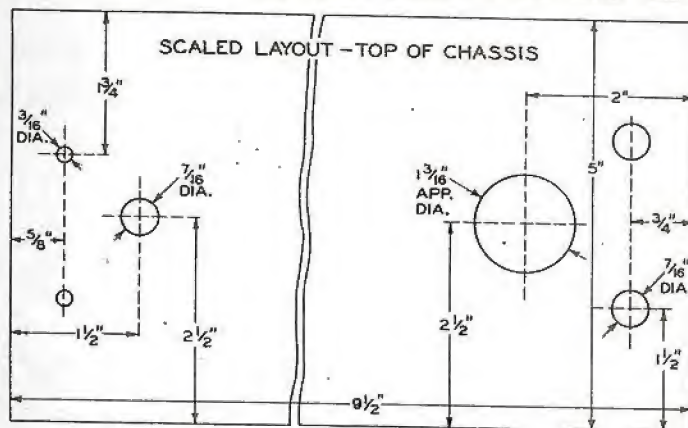
Templet Layout.

SMALL OSCILLATOR

(Continued from Page 2, Column 2)

the "E" section by an air gap made from two thicknesses of ordinary writing paper. This change permits the high-impedance side to handle the 815 plate and screen currents without saturation. Of course, the inductance is reduced, and the extreme low-frequency response is chopped off, but this is a desirable characteristic for speech modulation. It helps to make voice reproduction crisper and more intelligible, and at the same time reduces the amount of ac hum on the carrier. See QST, January 1946, page 51, "Link Coupled Modulator."

For the initial tune-up, connect a 25-watt Mazda lamp across the antenna hairpin loop. Then, with the feedback (grid circuit) plates set about ¼ inch from the 815 envelope, rotate the capacitor to a point where the tube oscillates. Next, squeeze or spread the plate tank to get the oscillator on frequency, and reset the grid capacitor. Then, adjust the antenna hairpin loop to give maximum RF with minimum coupling.

With a plate voltage of 400 volts and a plate current of 150 ma, there should be enough RF output to light a 25 watt lamp to full brilliancy. Those who have been there know that it takes much less than 15 watts of RF at 144 Mc to bring in R9 reports.

A 15-watt speech amplifier will put a great deal of audio on the carrier generated by this transmitter. The quality, as heard on a super-regenerative receiver, will be as good as the audio amplifier and modulator will permit.

Here is a hot little package that can be built at small cost, with a minimum of time and trouble—one that will "get you upstairs" and how!

PARTS LIST

L1 = Copper strap, ½" wide, 3" long, bent in shape of "U"
L2 = #14 wire, 3" long
L3 = Feed-through insulators.
L4 = Copper strap, ½" wide x 2" long, soldered to #12 wire, 2" long
L5 = Copper strap, ½" wide, 12" long, bent into hairpin, tapered to ¼" at each end.
L6 = RFC, #16 copper wire, 20" long, wound on ¼" mandrel.
L7 = Antenna hairpin, #12 wire, 10" long
R1 = 15,000 ohms, 2 watts, carbon
R2 = 10,000 ohms, 10 watts, wire wound
C1 = Mica capacitor, 500 $\mu\mu f$.
C2 = 5 plate variable capacitor
T1 = Universal output transformer, Thordarson T-13S42 or similar.
RCA-815 $6.25 at your distributor.
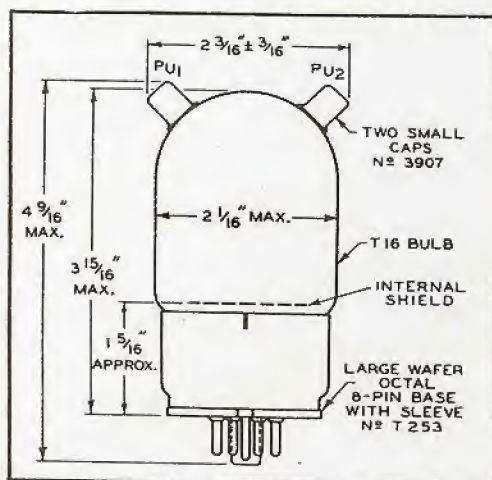
SIMPLE OSCILLATOR ALL SET TO GO
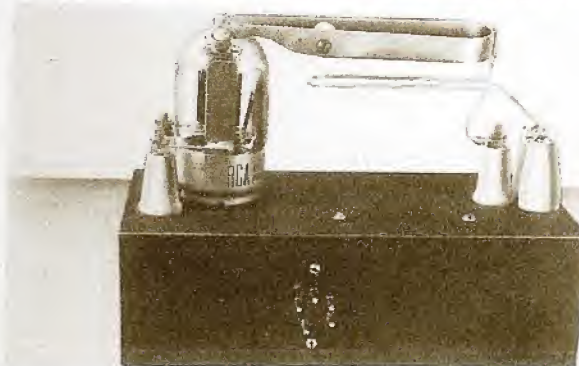
Top view of the transmitter. A little bit of copper and a few ceramic insulators put the 815 to work.

PUSH-PULL BEAM POWER AMPLIFIER

75 WATTS INPUT TO 2 METERS

Amateur Net **$6.25**

Features

RCA 815

- THE ABILITY OF THE 815 TO TAKE FULL POWER INPUT AT LOW PLATE VOLTAGE PERMITS THE USE OF A LOW-COST POWER SUPPLY.
- CLOSE SPACING OF THE PLATES REDUCES RADIATION LOSSES, AND SYMMETRICAL ARRANGEMENT OF THE ACTIVE ELEMENTS MAKES THE 815 IDEAL FOR VHF SERVICE.
- DOUBLE-ENDED CONSTRUCTION, EXCELLENT INTERNAL SHIELDING, AND LOW RESIDUAL GRID-PLATE CAPACITANCE MAKE THE 815 EASY TO NEUTRALIZE.
- THE GLASS BUTTON STEM, LOW-LOSS MICANOL BASE, AND THE GROUNDED METAL SHELL MAKE AN EXCELLENT FOUNDATION FOR THE RCA-815.

Application

Frequency Multiplication With push-pull grids and push-pull plates, the 815 is an excellent tripler. With push-pull grids and parallel plates, the 815 is a high-efficiency doubler.

Plate Modulation The 815 makes an excellent modulated final amplifier, with the screen-grid fed from the modulated plate supply through a series resistor by-passed for RF only.

Intermittent Telegraphy The 815 may be keyed in its grid, screen, or plate circuits. Under key-up conditions, electrode potentials should never exceed minus 175 volts on the control grids, 225 volts on the screen grids, or 600 volts on the plates.

Neutralization The high power gain of the 815 requires that the grid circuit be shielded from the plate circuit. Complete neutralization can be performed by putting a copper tab near each plate and connecting each tab to the opposite grid terminal.

Driving Power Requirements At moderate frequencies, the driving stage should furnish one watt of useful power. At 150 Mc the driver should have about 3 watts output. A pair of 6C4's in push-pull is recommended.

CHARACTERISTICS and RATINGS

Unless otherwise specified, values are for both units

HEATER (A. C. OR D. C.):		
Voltage per Unit	6.3	Volts
Current per Unit	0.8	Ampere
TRANCONDUCTANCE, for plate current of 25 ma.	4000	Micromhos
GRID-SCREEN MU-FACTOR	6.5	
DIRECT INTERELECTRODE CAPACITANCES (EACH UNIT):		
Grid-Plate (With external shielding)	0.2 max.	μμf
Input	13.3	μμf
Output	8.5	μμf

MAXIMUM CCS and ICAS RATINGS with TYPICAL OPERATING CONDITIONS

As Plate-Modulated Push-Pull R-F Power Amplifier—Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	CCS	ICAS	
D-C PLATE VOLTAGE	325 max.	400 max.	Volts
D-C SCREEN VOLTAGE (Grid No. 2)	225 max.	225 max.	Volts
D-C GRID VOLTAGE (Grid No. 1)	—175 max.	—175 max.	Volts
D-C PLATE CURRENT	125 max.	150 max.	Ma.
D-C GRID CURRENT	7 max.	7 max.	Ma.

	CCS	ICAS	
PLATE INPUT	40 max.	60 max.	Watts
SCREEN INPUT	4 max.	4 max.	Watts
PLATE DISSIPATION	13.5 max.	20 max.	Watts
TYPICAL OPERATION:			
D-C PLATE VOLTAGE	325	400	Volts
D-C SCREEN VOLTAGE #			
From a fixed supply of	165	175	Volts
From a series resistor of	10000	15000	Ohms
D-C GRID VOLTAGE of	—45	—45	Volts
From a grid resistor of **	11250	15000	Ohms
Peak R-F Grid-to-Grid Voltage	112	116	Volts
D-C PLATE CURRENT	123	150	Ma.
D-C SCREEN CURRENT	16	15	Ma.
D-C GRID CURRENT (Approx.)	4	3	Ma.
Power Output (Approx.)	30	45	Watts

As Push-Pull R-F Power Amplifier and Oscillator—Class C Telegraphy

Key-down conditions per tube without modulation

	CCS	ICAS	
D-C PLATE VOLTAGE	400 max.	500 max.	Volts
D-C SCREEN VOLTAGE (Grid No. 2)	225 max.	225 max.	Volts
D-C GRID VOLTAGE (Grid No. 1)	—175 max.	—175 max.	Volts
D-C PLATE CURRENT	150 max.	150 max.	Ma.
D-C GRID CURRENT	7 max.	7 max.	Ma.
PLATE INPUT	60 max.	75 max.	Watts
SCREEN INPUT	4.5 max.	4.5 max.	Watts
PLATE DISSIPATION	20 max.	25 max.	Watts
TYPICAL OPERATION:			
D-C Plate Voltage	400	500	Volts
D-C Screen Voltage			
From a fixed supply of	145	200	Volts
From a series resistor of	15000	17500	Ohms
D-C Grid Voltage			
From a fixed supply of	—45	—45	Volts
From a cathode resistor of	260	265	Ohms
From a grid resistor of**	10000	13000	Ohms
Peak R-F Grid-to-Grid Voltage	116	112	Volts
D-C Plate Current	150	150	Ma.
D-C Screen Current	17	17	Ma.
D-C Grid Current (Approx.)	4.5	3.5	Ma.
Power Output (Approx.)	44	56	Watts

\# Fixed supply, modulated simultaneously with the plate supply, is recommended. Series resistor connected to *modulated* plate-voltage supply may also be used.

** The grid-circuit resistance should never exceed 15000 ohms (total) per tube, or 30000 ohms per unit. If additional bias is necessary, a cathode resistor or a fixed supply should be used.

FINAL AMPLIFIER USING PAIR OF RCA-813's IS A DX DEMON

"SUPER-SLUGGER" HIGH POWERED FINAL
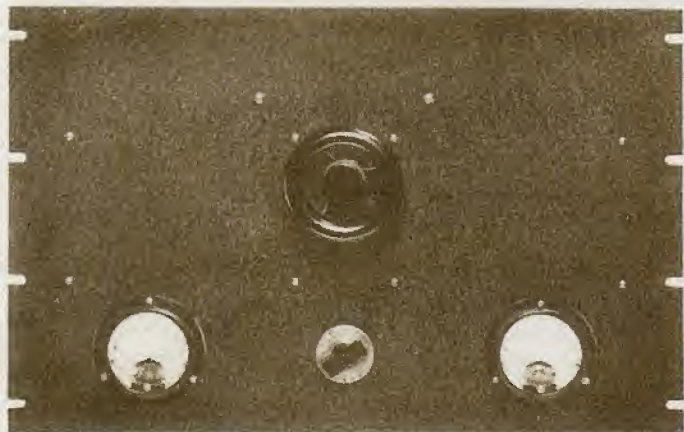
Panel view of the unit which uses a pair of RCA-813's, has low drive requirements and automatic correction of L/C ratio for all bands.

COMPACT OSCILLATOR A GIANT PERFORMER FOR 2 METER WORK

By J. H. OWENS
W3ASZ/2
Amateur Sales. RCA Tube Department

Try this one for size! And if you are one of those Hams who agree that good things comes in small packages, you will like the "Ninety-Ninety" oscillator.

The "Ninety-Ninety", or "90+90", if you prefer, is exceptionally small and compact. But the components are not overly crowded. In fact, as can be seen from the photographs, there is space enough for the modulation transformer in a cabinet only 3" x 4" x 5"— just in case you want to use plate-and-screen modulation.

Starting at the beginning, the 90+90 is a push-pull oscillator, having a tuned plate tank and a tuned grid tank. Intermediate between the two, and coupled to both of them is a third tank circuit, also tuned. That makes three tank circuits, all tuned to the same frequency, and all doing their utmost to hold the transmitter on frequency.

Ninety-Ninety, you see, is not just the name of the oscillator, it is also a significant expression for the principle of operation.

Electromagnetically speaking, two loosely-coupled tank circuits are 90 degrees apart in phase, and if a third one is loosely coupled to the second (and properly polarized), there will be a total phase shift of "90 plus 90" or 180 degrees.

The meaning of all this is that a tube will oscillate at the resonant frequency of its grid and plate tank circuits only when they are both tuned to the same frequency, and are exactly 180 degrees out of phase. Under any other condition, the frequency will have to deviate from resonance to provide the reactance necessary for this phase difference.

The surprising characteristic of the Ninety-Ninety is the way it "tracks" in tuning. When it is properly adjusted, the points of

NOVEL RIG COVERS 10-80 BAND FOR PHONE OR CW APPLICATION

By M. L. "Doc" REDMAN
W2PBX (Ex-W9ENK/2)
Manager, Electron Microscope Section, RCA Service Co., Inc.

Four months ago this station put a pair of RCA-813's in a new final amplifier, and shoved a full kilowatt into them. They took the soup without blushing, and the recent announcement of new tube ratings has proved our point. The new post-war RCA-813's are bigger and better than ever, and the reduced price of $14.50 makes them the logical choice for that high-powered final.

A casual inspection of the pictures will show no parasitic chokes, or other electrical or mechanical corrective gadgets. Instead, observation reveals symmetry, and complete band coverage from 10 to 80. The thing we like best of all is the feature that the plug-in coils can be changed from either side, top, or rear, whichever is most convenient.

What more do you want in a unit of this kind? Quick band change without neutralization? Low drive requirements? Provisions for both phone and CW operation? Automatic correction of L/C ratio for all bands? No bugs, parasitics, or other forms of electronic vermin? Ease of construction with ordinary hand tools? You get all these and "heavenly reports too" with the 813 "Super Slugger".

As can be seen, the transmitter is built around a pair of National TMA-100-DA split-stator variable condensers, a Millen 10,000 worm gear drive unit, a set of B & W type TVH plate tank coils, a set of National AR-16 grid coils, and of course, a pair of those big beam "bottles".

The two variable condensers are mounted end-to-end into the worm
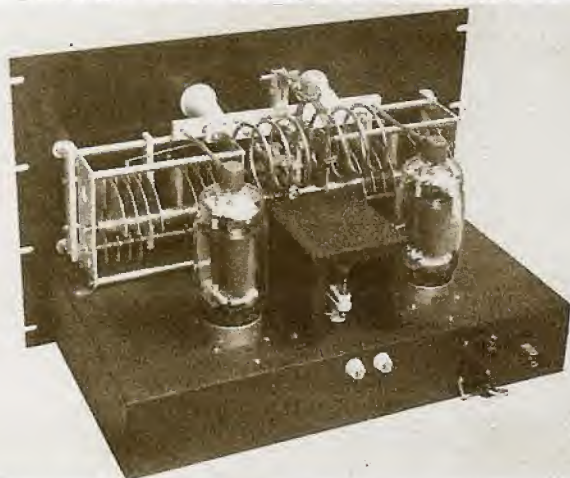
"NINETY-NINETY" RARIN' FOR THE AIR
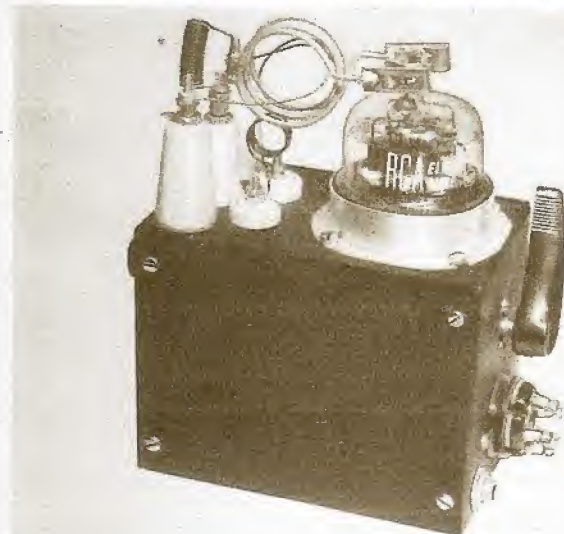
This diminutive oscillator develops remarkable power output even though it is housed in a 3" x 4" x 5" cabinet.

DESIGNED FOR SYMMETRY AND EFFICIENCY

Rear view of "Super-Slugger" reveals clever removable shield which permits coils to be changed with maximum convenience.

NOVEL RIG

(Continued from Page 1, Column 4)

drive unit. In this arrangement, they serve as chassis mounting brackets as well as the source of capacitive reactance. The frame bases are bolted to the panel, and the frame sides are bolted to the chassis by means of ½″ angle brackets. A very substantial mechanical linkage is the result.

All four sections of the condensers are used for 80 and 40, and only one section of each condenser for 20 and 10 meters. Adequate capacitance is supplied on all bands by this arrangement. Two turns were removed from the 80-meter coil, as well as from the 40, 20, and 10-meter coils. This was done to keep harmonics to a minimum, and to keep the signal extra sharp so as to prevent BCL interference. (We are apartment house dwellers.)

Circuits Isolated

The final tank-coil swinging-link assembly is suspended from the panel with two 1¾″ insulators, which almost places the soldering lugs of the unit directly above the connecting points on the condensers. It is not possible to see the plate rf choke which is mounted on a feed-through insulator located between the panel and gear drive. This placement aids in further isolating the grid and plate circuits. The screen circuit is conventional with a possible exception that each tube is individually by-passed to ground and that the plate by-pass capacitor is connected to the screen circuit. This is done for best phone performance, as it serves to prevent loss of high-frequency audio response. It will be noticed by referring to the bottom view of the chassis that all by-pass capacitors from the screen and filament leads are connected directly to ground in the region of each socket through socket mounting bolts. One mica filament capacitor is located at each socket, by-passing one and the other side of the filaments. The beam-

forming plates are placed at ground potential through connection to socket mounting bolts.

One method of supplying the screen voltage, consists of a voltage divider circuit which automatically prevents the screen voltage from rising to the plate potential if the space current is reduced to zero. Details for determining values for the voltage divider circuit will be found in an article "Fool Proof Screen Feed" by W. E. Roberts, Radio Corporation of America, Page 38, October 1940 QST.

The screen grids can also be fed from the plate supply through a series resistor, or they can be fed from a separate supply. If either of these methods is employed and the amplifier is used for CW work, precautions must be taken to prevent excessive screen dissipation or voltage during key-up conditions.

All grid components are completely isolated from the plate circuit. This is imperative to prevent self-oscillation of the tubes. The plug-in grid coil is housed in a removable shield above the chassis

which plugs in like a coil assembly, facilitating quick coil changing.

Short direct connections from the grid coil to the grid condenser and then to the grid proper is made possible by placing the grid condenser between the two sockets. It will be noted that the grid bias terminal at the back of the chassis is grounded externally. This is not an innovation but rather was done for convenience at this station. Fixed bias is placed in the grid circuit by removing the grounded plug and substituting one from the bias supply. Grid-leak bias has been used entirely for phone operation. However, it is good practice to combine fixed bias with grid-leak bias for purposes of tube protection, during periods of no excitation, whether caused by key-up periods or by failure of a preceding stage.

More than sufficient excitation was supplied to the amplifier from 80 through 10 meters from a con-

"Super-Slugger" Schematic

servatively operated 807 doubler. The needle of the 25 milliampere meter in the 813 grid circuit can be pushed to the pin with only 30 to 50 plate mils at 450 volts to the 807.
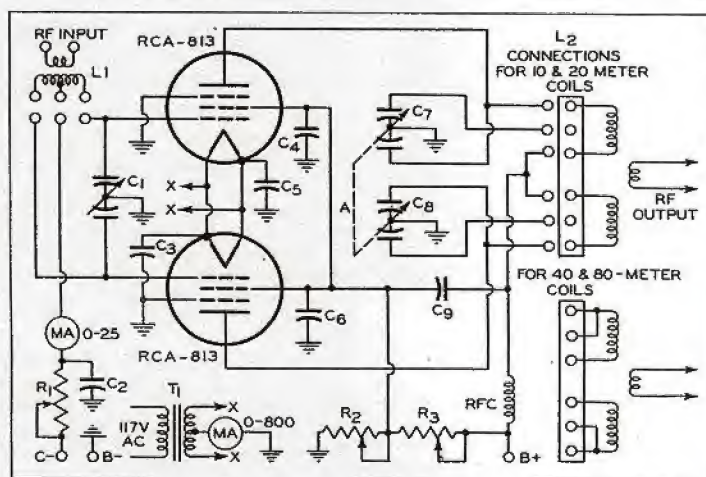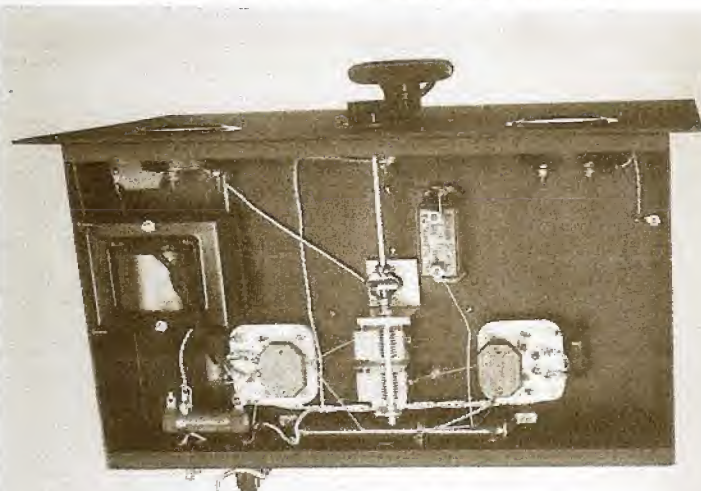
Meter Functions

The plate and grid meters are conventionally located in the circuit. The plate meter is in the cathode circuit, and therefore reads the total of screen, plate, and grid currents. All circuits, screen, grid, and plate, have been checked individually and this probably should be considered recommended procedure because too high screen current and voltage will result in excessive dissipation while too low screen voltage will reduce the output. If the grid-leak resistor is returned to the top side of the plate current meter instead of to ground the plate meter will not read grid current.

The unit is entirely free of parasitics and remains stable during periods of 100% modulation. Many compliments have been received commenting on the sharp powerful signal and fine 'phone quality. Probably the nicest one comes from W2PLF who admired the amplifier's efficiency and performance to the point of constructing an identical unit.

PARTS LIST

L1 National AR-16 center-link coils.
L2 B & W type TVH (see text).
A Millen 10,000 worm drive gear.
CI 100 μμf per section, split-stator, variable.
C2 0.006 μf, 500 volt, mica.
C3, C5 0.002 μf, 500 volt, mica.
C4, C6 0.003 μf, 2500 volt, mica.
C7, C8 50 μμf per section, split-stator, variable, 0.171″ spacing.
C9 0.002 μf, 5000 volt, mica.
R1 25,000 ohm, adjustable, 25 watt, WW.
R2 25,000 ohm, adjustable, 25 watt, WW.
R3 50,000 ohm, adjustable, 75 watt, WW.
T1 10 volt, 10 ampere, filament transformer.
RFC National R-175 or R-154U.

SIMPLE MECHANICAL WORK AND WIRING

Bottom view of the final amplifier shows how all grid components are completely isolated from plate circuit to prevent self-oscillation of tubes.

807 XTAL. OSCILLATOR CONVERTS THIS RIG FROM 40 TO 15 METERS

By J. L. REINARTZ
Power Tube Group, RCA Lancaster Engineering Section

I was asked the other day what I would do to my transmitter to be able to operate in the 15-meter band. My solution would be to use a suitable 40-meter crystal, which I have, and triple to the 15-meter band in the plate circuit of an 807 crystal oscillator.

A laboratory set-up proved the point. The 807 crystal oscillator operated well at the fundamental, the second and the third harmonic, and proved capable of driving an 813 at 21 Mc. The following circuit arrangement was used and can readily be duplicated.
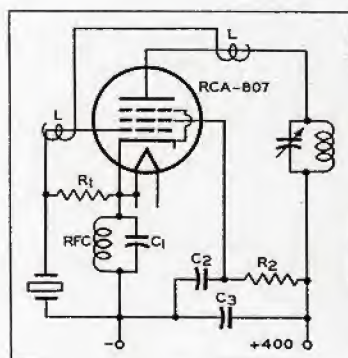
PARTS LIST

C1 100 $\mu\mu f$ midget, mica.
C2 0.005 μf midget, mica.
C3 0.005 μf midget, mica.
L, L Piece of insulated wire looped one or two turns around plate and grid leads.
R1 25,000 to 50,000 ohms, 2 watt carbon.
R2 25,000 ohms, 5 watt WW (50,000 ohms if plate supply exceeds 500 volts).
RFC Single layer coil, #24 enameled wire, coil 1½ inches long, ⅜ inch diameter.

COMPACT OSCILLATOR

minimum plate current, maximum grid current, and maximum rf output will all fall at the same points of tuning. This is a good indication that the grid and plate tanks are separated by two 90-degree phase shifts.

The plate tank is on top of the chassis, and is supported by the Fahnstock plate clips and the rf feed choke. It is tuned by the expedient of squeezing or spreading the turns.

Loose Coupling

Mounted on two feed-through insulators, and very loosely coupled to the plate tank, is the pick-up coil that feeds the intermediate coupling tank. This tank is tuned by a variable condenser, and is in turn very loosely coupled to the grid tank, which is also condenser tuned. The desired result is accomplished. (A lot of tanks, eh, what?)

The accompanying photographs, the circuit diagram, and the parts legend, illustrate the oscillator well enough to make it easily duplicated. That leaves little else to put in writing except some pointers derived from experience in the building of three models.

The first point to be kept in mind is that the three tanks must be loosely coupled. If they are closely coupled, the tuning will be broad, and the setting for maximum grid current and rf output will not track with the plate current dip.
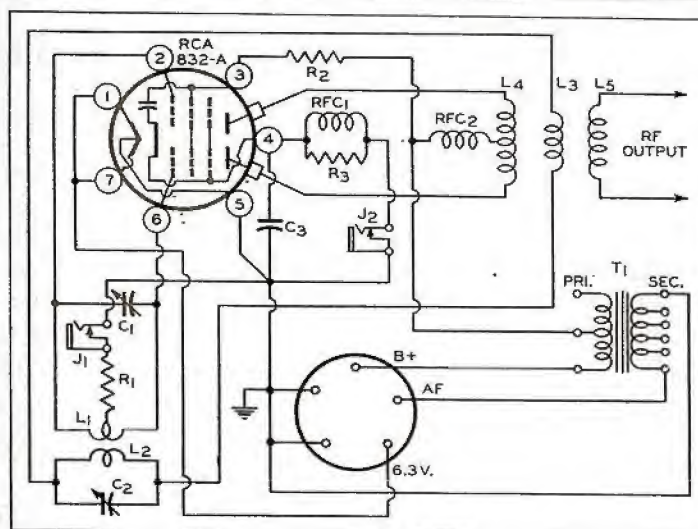
The second point for attention is the adjustment for optimum grid drive. The tendency may be toward too little grid drive with loose coupling. If this happens, it can be corrected by using more inductance and less capacitance in the grid tank. The use of more wire in the intermediate tank pickup coil also helps to provide more drive with a given degree of coupling to the plate tank. Use of the smallest amount of grid current that will provide upward modulation is recommended.

Final Adjustment

The third and last point, is to make sure that the intermediate tank pickup loop is properly polarized. If it is wound in the wrong direction, the oscillator will not function when all circuits are tuned to resonance. Instead, oscillations will occur when the intermediate tank is tuned to either side of resonance! Reversing the winding will correct this in a jiffy.

Either the 832-A or the 829-B will give good performance at 1¼ as well as 2 meters. The 829-B has higher input and output capacitance, therefore will require less inductance and capacitance in the tank circuits. The 815 performs nicely at 2 meters, but should not be expected to work the higher frequency band. A pair of 2E26's can also be used with good results. As illustrated, the oscillator will work only the 2-meter band.

The initial tune-up should be done with reduced power on the tube. A milliammeter should be connected in series with the plate and screen voltage supply. Also, a milliammeter should be connected in series with the grid-bias resistor, or a voltmeter should be connected across it. A 15-watt incandescent lamp should next be connected across the antenna pickup loop.

The grid tank condenser and the intermediate tank condenser should be tuned for maximum rf output. Then the plate tank coil should be squeezed or spread to get the oscillator on frequency, and the variable condensers should be tuned again. Preliminary adjustments should be made for lowest plate current.

In the final adjustment, the point of minimum plate current will track with the point of maximum grid current to develop the greatest power output, and then the Ninety-Ninety will prove deserving of its name.

Compact Oscillator Schematic

PARTS LIST

L1 Grid tank, 7 inches #12 wire in hairpin loop.
L2 Intermediate coupling tank, 7 inches #12 wire in hairpin loop.
L3 Pickup coil, 4 turns #18 wire, ½ inch diameter coil.
L4 Plate tank, 3 turns #10 wire, 1½ inches diameter coil.
L5 Antenna coil, 1 inch diameter, 2 turns #18 wire.
C1 6 plate midget variable, ceramic frame.
C2 9 plate midget variable, ceramic frame.
C3 500 $\mu\mu f$ midget mica, 500 volt.
R1 30,000 ohm, 5 watt, WW (2 watt carbon Okay).
R2 15,000 ohm, 5 watt, WW.
R3 100,000 ohm, 2 watt, carbon.
RFC1 38 inches #26 DSC wound on R3.
RFC2 20 inches #18 enameled wire wound on ¼ inch mandrel, coil 1 inch long.
J1 & J2 Closed circuit phone jack.
T1 Universal output transformer, 10 watt size, with air-gap in core.

SMALL, COMPACT, BUT NOT CROWDED
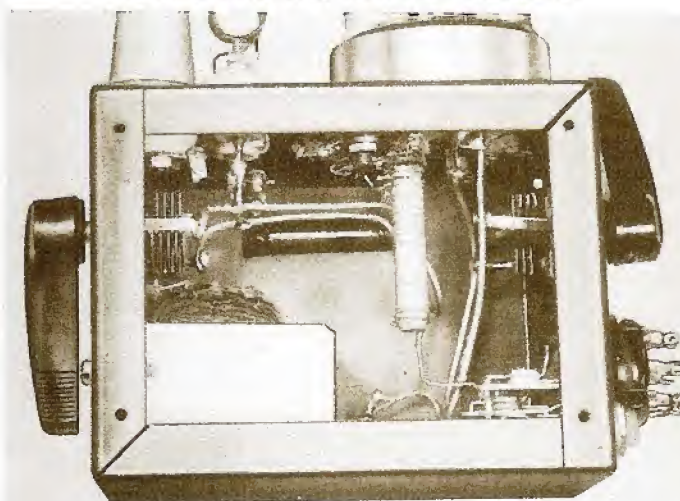
Well planned placing of components in the 3" x 4" x 5" cabinet leaves sufficient space to work with soldering iron and tools.

RCA-813 TRANSMITTING BEAM POWER AMPLIFIER

500 WATTS INPUT TO 30 MEGACYCLES

Amateur Net $14.50

RCA 813

Features

- *No Neutralization.* QUICK BAND CHANGE FROM "EIGHTY" TO "TEN".
- *High Power Gain.* ABOUT 4½ WATTS OF DRIVING POWER IS REQUIRED.
- *Real Ham Value.* THIRTY-FOUR-PLUS WATTS-PER-DOLLAR.
- *High Efficiency.* FULL PLATE-CIRCUIT EFFICIENCY AS HIGH AS 30 MC.
- *Low Screen Current.* MORE EFFICIENT USE OF DC AND AF POWER.

Behind the superb performance features of the RCA-813 are the following important electrical and mechanical design features:

1. Element supporting dome-top bulb.
2. Low-resistance, dual-ribbon plate leads.
3. Pure, gas-free, alumina insulators.
4. Electron-confining capacitance shield.
5. 50-watt thoriated-tungsten filament.
6. 125-watt non-warping graphite anode.
7. Nonex hard-glass straight-side bulb.
8. Unobstructed guarded getter.
9. Low-loss glass-dish stem.
10. Drawn tungsten metal-to-glass seals.
11. Short-leads for low internal inductance.

Application

Driving Power. A small crystal oscillator will provide adequate drive at frequencies of 3 to 7 Mc. At 30 Mc., an 807 doubler will drive a pair of 813's, with power to spare.

Shielding. The high power gain of the 813 necessitates complete shielding of the grid circuit from the plate circuit. Neutralization is not required.

Plate Modulation. The screen grid must be modulated simultaneously with the plate. The screen grid voltage can be taken from a fixed supply, fed through a modulation transformer winding. A less efficient but equally satisfactory method is to feed the screen grid through a dropping resistor connected to the modulated plate supply.

Class C Telegraphy. Under key-up conditions, the screen grid potential should not exceed 800 volts. If a preceding stage is keyed, a fixed bias of about 45 volts should be used to limit the plate current to a safe value.

Frequency Multiplication. Use Class C telegraphy ratings, but increase grid bias and grid current to point that produces optimum efficiency. Proper values will be approximately twice those given.

RF Bypassing. In plate-modulated telephony service, where the screen grid is fed through a series resistor from the modulated plate supply, the plate-circuit should be by-passed to the screen grid, and the screen grid should be by-passed to cathode. The screen by-pass capacitor should be about three times as large in value as the plate capacitor.
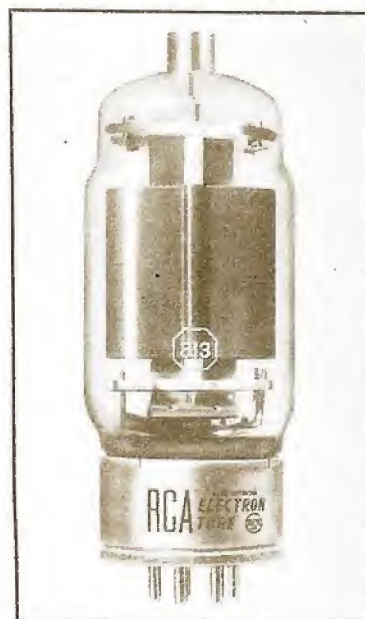
NEW RATINGS — RCA-813

Plate-Modulated R-F Power Amplifier—Class C Telephony

Maximum Ratings, Absolute Values

	CCS	ICAS
D-C Plate Voltage	1600 max.	2000 max. volts
D-C Screen Voltage (Grid No. 2)	400 max.	400 max. volts
D-C Grid Voltage (Grid No. 1)	—300 max.	—300 max. volts
D-C Plate Current	150 max.	200 max. ma.
D-C Grid Current	25 max.	30 max. ma.
Plate Input	240 max.	400 max. watts
Screen Input	15 max.	20 max. watts
Plate Dissipation	67 max.	100 max. watts

Typical Operation

D-C Plate Voltage	1250	1600	2000 volts
D-C Screen Voltage*	400	400	350 volts
From a series screen resistor of	53,000	60,000	41,250 ohms
D-C Grid voltage**	—120	—130	—175 volts
From a grid resistor of	30,000	21,600	41,000 ohms
Peak R-F Grid Voltage	195	210	300 volts

SEE PAG3 NOV-DEC 1946

D-C Suppressor Voltage (Grid No. 3)	0	0	0 volts
D-C Plate Current	150	150	200 ma.
D-C Screen Current	16	20	40 ma.
D-C Grid Current (Approx.)	4	6	10 ma.
Driving Power (Approx.)	0.7	1.2	4.3 watts
Power Output (Approx.)	135	175	300 watts

*Obtained preferably from a fixed supply modulated simultaneously with plate voltage, or from modulated plate supply through series resistor of value shown.

**Obtained from a grid resistor of value shown or from a combination of grid resistor with either fixed supply or cathode resistor. Total effective grid circuit resistance should not exceed 30,000 ohms.

R-F Power Amplifier and Oscillator—Class C Telegraphy

Maximum Ratings, Absolute Values

	CCS	ICAS
D-C Plate Voltage	2000 max.	2250 max. volts
D-C Screen Voltage (Grid No. 2)	400 max.	400 max. volts
D-C Grid Voltage (Grid No. 1)	—300 max.	—300 max. volts
D-C Plate Current	180 max.	225 max. ma.
D-C Grid Current	25 max.	30 max. ma.
Plate Input	360 max.	500 max. watts
Screen Input	22 max.	22 max. watts
Plate Dissipation	100 max.	125 max. watts

Typical Operation

D-C Plate Voltage	1250	1500	2000	2250 volts
D-C Screen Voltage†	300	300	400	400 volts
From a series resistor of	27,000	40,000	36,000	46,000 ohms
D-C Grid Voltage‡				
From a fixed supply of	—75	—90	—120	—155 volts
From a grid resistor of	6000	7500	12,000	10,000 ohms
From a cathode resistor of	330	400	520	565 ohms
Peak R-F Grid Voltage	160	175	205	275 volts
D-C Suppressor Voltage (Grid No. 3)	0	0	0	0 volts
D-C Plate Current	180	180	180	220 ma.
D-C Screen Current	35	30	45	40 ma.
D-C Grid Current (Approx.)	12	12	10	15 ma.
Driving Power (Approx.)	1.7	1.9	1.9	4 watts
Power Output (Approx.)	170	210	275	375 watts

†Obtained from a separate source, from the plate-voltage supply with a voltage divider, or through a series resistor of value shown. Series screen resistor should be used only where the 813 is employed as a buffer amplifier and is not keyed. The screen voltage must not exceed 800 volts under key-up conditions.

‡If preceding stage is keyed, partial fixed bias is required.

NEW "HAM" RATINGS ANNOUNCED FOR RCA RECEIVING TUBES

GRID CONTROLLED POWER SUPPLY IS A VERSATILE UNIT

Uses Pair of RCA-2050's for Wide Voltage Range

*By J. H. Owens, W2FTW
and G. D. Hanchett, W1AK/2*

A power supply that will deliver up to 200 Ma at any voltage from about 50 to 400 volts! Does this appeal to you? If it does, and if you want this convenience at low cost without the losses of tapped bleeder resistors or expensive variable transformers, but with good voltage regulation, just by setting a small potentiometer—here's how!

It's done with grid-controlled rectifiers, commonly known as thyratrons. And what are they? They are simply rectifiers containing gas to reduce the voltage drop and to improve the efficiency, and having one or more grids interposed between the plates and cathodes to control the start of plate current flow.

In the power supply to be described, a pair of RCA-2050's are used to deliver the current at the desired voltage. Within its capabilities a unit like this permits the convenient reduction of power during tune-up of that new rig, and a moment later, its operation at full input. For experimental work, such a unit is an invaluable laboratory tool.

Theory of Operation

Refer to Figure 1 which illustrates the critical control characteristics of a thyratron tube. The heavy solid line represents the ac voltage impressed on the plate of one of the rectifiers in a full-wave circuit; and the dashed line represents the critical instantaneous grid voltage that must simultaneously be put on the control grid of this tube to prevent it from ionizing or "firing". In this condition, neither tube will pass plate current, and the output of the rectifier will be zero.

The dotted line represents an in-phase voltage which, if impressed upon the grid of the thyratron, will cause it to fire at the start of the cycle and conduct throughout its duration, at which time the plate

(Continued on Page 3, Column 1)

THIS MONTH'S PRIZE WINNER

James E. Hausser, W8LB, Cleveland, Ohio, takes top honors this month for this photo of his RCA tube equipped rig. Jim writes in to say he has worked Maine to California on 10-meter phone with R9 plus reports.

The lower right unit is the rf section; a Meissner Signal Shifter feeds an 807 which works into push-pull 807's. The unit at lower left houses the power supply, the modulation transformer, and the complete bias supply for the transmitter. Modulator is an RCA 50-watt amplifier, and the microphone, an RCA-MI-6206. Nice going, Jim, for a swell looking rig. Your $10.00 check is in the mail.

And to the rest of you tinkering, ingenious "Hams", let's have some photos of those rigs you've gotten together. Remember—if it's RCA tube equipped, you stand a bang-up chance to walk off with the month's prize money.

DATA GUIDES RECEIVING TYPE USE IN LOW POWER TRANSMITTER STAGES

For you Hams who use receiving tubes for low power transmitting applications—and was there ever a Ham who did not—here are regular rf class C ratings for nine popular RCA receiving types. These tubes are favored for oscillators, buffers, frequency multipliers, and low-power final amplifiers because they supplement the regular line of small transmitting tubes. Therefore, most of them have become standard equipment in Ham Shacks. Their limitations, however, have frequently been a matter of conjecture. With the new ratings now established, all Amateurs have a reliable guide for obtaining the most hours of useful life from RCA receiving tubes in transmitting applications.

For Hams Only

When we said the new ratings were established for you, the Amateurs, we meant *only* and *solely* and *strictly* for you, and for no one else. However, because Amateur rf use of these tubes represents something less than one per cent of the main use of the tubes, their characteristics cannot be determined solely by the requirements of this particular class of service.

In the course of time, receiving tubes may be modified to give major users more performance for less money. Progressive work of this nature has resulted in benefits well known to those who use the tubes. Unfortunately, such progress may result in changes in tubes which, although representing real improvement in their normal receiver function, may require redesign of transmitter equipment in which the tubes are used.

Hams welcome improvements and price reductions in tubes, and are quick to modify their gear to adjust for or take advantage of any changes which may be made. Manufacturers, on the other hand, rightfully expect and demand that no changes be made in tubes which will adversely affect their performance in commercial or production equipment. Therefore, manufacturers should not use these tubes according to the Ham ratings.

It should be recognized that Ham ratings are subject to change at a moment's notice and some of them may even be withdrawn.

Proceed With Caution

A quick examination of the accompanying table shows that the tubes have been given higher input ratings than heretofore. No longer do you have to learn the hard way what the margin of safety is for receiving tubes in transmitting practice, that is, by blowing up tubes. The tubes will take just as much, but no more, power input than be-

(Continued on Page 2, Column 1)

RECEIVING TUBE CLASS C TELEGRAPHY RATINGS ⚹ EXCLUSIVELY FOR THE HAM

RCA Tubes (Type)	Maximum Plate Supply (Volts) E_{bb}	Maximum Screen Grid (Volts) E_{c_2}	Maximum Control Grid (Volts) E_{c_1}	Maximum Plate (Milliamperes) I_b	Maximum Screen Grid (Milliamperes) I_{c_2}	Maximum Control Grid (Milliamperes) (Note 2) I_{c_1}	Maximum Plate Dissipation (Watts) P_p	Maximum Screen Grid Dissipation (Watts) P_{c_2}	Power Output (Watts) (Note 1) P_o	Maximum Frequency (Megacycles)* M_c	Grid Bias Calculator Mu Factor (Approximate)† μ	Grid to Plate Capacitance (uuf) C_{gp}	Input Capacitance (uuf) C_{in}	Output Capacitance (uuf) C_{out}
6AG7	375	250	— 75	30	9	5.0	9.0	1.5	7.5	10	22	max. 0.06	13	7.5
6AK6	375	250	—100	15	4	3.0	3.5	1.0	4.0	54	9.5	0.12	3.6	4.2
6AQ5	350	250	—100	47	7	5.0	8.0	2.0	11.0	54	10	0.35	7.6	6.0
6C4	350	—	—100	25	—	8.0	5.0	—	5.5	54	18	1.6	1.8	1.3
6F6	400	275	—100	50	11	5.0	12.5	3.0	14	10	7	0.2	6.5	13
6L6	400	300	—125	100	12	5.0	21	3.5	28	10	8	0.4	10	12
6N7	350	—	—100	30 (per plate)	—	5.0 (per grid)	5.5 (per plate)	—	14.5 (total)	10	35	—	—	—
6V6GT	350	250	—100	47	7	5.0	8.0	2.0	11.0	10	9	0.7	9.5	7.5
12AU7	350	—	—100	12 (per plate)	—	3.5 (per grid)	2.75 (per plate)	—	6.0 (total)	54	18	1.5	1.6	0.5 (approx.)

Notes (1) Power output based upon plate circuit efficiency of 70%.
      (2) 100,000 ohms maximum grid resistor.
      * Maximum frequency for full power output and input.
† For pentodes this is the grid-screen amplification factor.
⚹ Maximum ratings are absolute maximum values not to be exceeded under any conditions of operation.

NEW "HAM" RATINGS

fore, the difference is that now you have exact information on which to base your operating practice.

In return for this confidence, it is expected that you will accept the ratings in good faith and not attempt to "stretch" them further. Reduced power should be used during tune-up, and other precautions taken to keep the tubes within the ratings.

Screen Grid Tubes Critical

Many of you Hams have found that triodes will stand more abuse than pentodes. The reason is that with pentodes and beam tubes it is comparatively easy to overload the screen. In triodes, the important limiting factor usually is only plate dissipation. Thus, in screen grid tubes we have two important limiting conditions, screen dissipation and plate dissipation. The need to watch both dissipation limits in the case of screen grid tubes is the price that has to be paid for the additional advantages gained. Good design practice indicates that the screen grid voltage should be adjusted at about 80% of the maximum value shown in the table.

When screen grid tubes are used as class C amplifiers, the screen current goes up directly with an increase in applied grid drive. This means increased screen dissipation. Therefore, grid driving power should be kept as low as possible, consistent with good power conversion efficiency.

General Application Notes

Specific conditions were not set up for the tubes as plate-modulated or plate-and-screen modulated amplifiers, because this use is a minor one. When such service is contemplated, the plate voltage should be reduced 20%, the screen grid (if present) voltage maintained, and the grid drive adjusted as recommended for doubler service. These modifications will protect the tubes and take into account the additional grid drive that is necessary.

When tubes are used as doublers or triplers, their efficiency is less than when they are used as straight-through amplifiers. For example, the plate circuit efficiency of a class C amplifier can easily be 70%, but the efficiency of a multiplier will ordinarily be something near the reciprocal of the order of the harmonic; viz., 50% (=½) for a doubler, and 33 1/3% (=1/3) for a tripler.

The significance of this is that because the efficiency is less, less power gets transferred to the load, hence more is dissipated in the tube. Therefore, as the plate efficiency goes down, the power input must also go down, otherwise the plate and screen dissipation ratings may be exceeded.

Tubes used as oscillators should be handled quite like class C amplifiers. The big difference between the two is that in oscillator service, the tubes must supply their own driving power. The power output will be equal to the plate power input, minus grid-driving power, copper losses, dielectric losses, radiation losses, harmonic losses, and the power dissipated in the plate and other tube electrodes. Efficiencies vary more widely in oscillators than in amplifiers, and on an average range from 25 to 60%.

Frequency Limits

The tubes may be operated at frequencies higher than those given in the table, but of course the power output will go down accordingly. As the power goes down, the plate (and screen) dissipation goes up; therefore, the power input must be reduced to prevent dissipation ratings from being exceeded.

As an indication of service ability, the octal types in the table perform usefully in the six-meter band, while the miniatures give a fair account of themselves in the two-meter band. To be on the safe side at these higher frequencies, reduce all ratings about 20% from the values shown in the table.

Neutralization

With the possible exception of 3 types, all of the tubes in the group positively require neutralization when used as 1 to 1 amplifiers. It may be possible to use the 6AG7, 6AK6, and 6F6 (metal) without neutralization because the average tube has relatively low grid-plate capacitance. This characteristic is usually not strictly controlled in production because it has no impor-

tance in audio output applications. Neutralize all the tubes and be sure.

Amplifier and Oscillator Conditions

Now we get down to the pleasurable business of putting the tubes to work, and the question is, "How do we use the new ratings?" They are all maximum permissible values, while the Amateur demand is for "typical operating conditions".

For oscillator and amplifier service, divide the plate voltage by the Mu factor. For a beam tube or pentode, divide the screen grid voltage by the Mu factor. This gives you the approximate bias for plate current cutoff. Double this and you have the correct value for class C operation. For the 6C4 with 350 plate volts grid bias will be approximately 40 volts.

The value of grid current is an arbitrary one. We have selected 80% of the maximum rated value as a satisfactory figure. That gives 6.5 Ma for the 6C4. The grid-leak bias resistor can be selected by dividing the grid bias by the grid current. Thus $40 \div 0.0065 = 6,000$ ohms (approx.) which is the proper value for the 6C4. It should be noted that 100,000 ohms is the maximum amount of resistance that should be used in the grid circuit of any of the tubes in the table.

Typical Multiplier Conditions

For doubler service, divide the plate voltage by the Mu factor, and multiply by three. Calculate the value of grid-leak bias resistance in the same manner as in amplifier and oscillator conditions. Normal grid current will be the same.

The foregoing grid-bias formulas anticipate normal power output and plate circuit efficiency consistent with minimum grid drive and the least amount of unwanted harmonics. Higher bias will make possible somewhat more output at the expense of increased grid-drive requirements. Optimum conditions for frequency multiplier service may demand bias values near the maximums shown in the table.

A FEW OF THE TUBES HAVING NEW HAM RATINGS

Amateurs now have a reliable guide for obtaining the most hours of useful life from these tubes in transmitting applications.
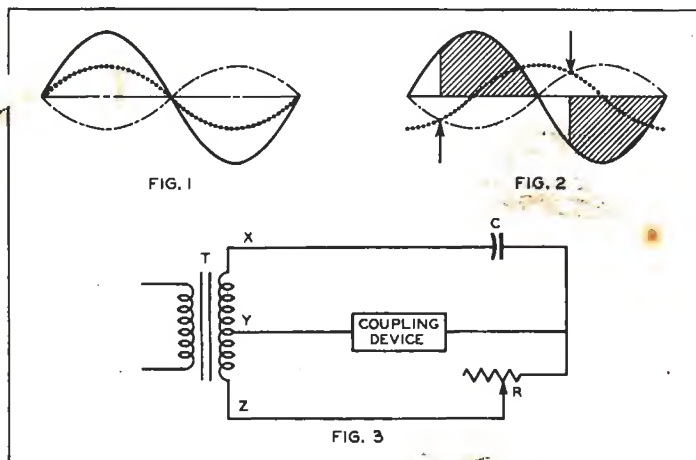
Control characteristics of thyratron tubes and a basic phase controlling network.

POWER SUPPLY

(Continued from Page 1, Column 1)

voltage drops to zero and the tube deionizes, thereby restoring grid control. In this condition, both of the tubes act like regular diode rectifiers and deliver maximum power to the load.

Figure 2 shows the relationship of plate voltage versus critical-grid-voltage when a voltage of 90° displacement is impressed on the grid. The arrows indicate the instant where the actual negative grid voltage becomes more positive than the critical voltage for the applied plate voltage. At this point, ionization occurs, and current flows during the remaining part of the cycle as indicated by the shaded area. The dc output voltage delivered by the filter will be about three-quarters of the maximum obtainable. From this, it can be seen that variations in phase between applied anode voltage and grid voltage will produce more or less rectifier output. Carried to extremes, this means either full-voltage at full conduction or zero-voltage at zero conduction.

Phasing Circuit

Figure 3 shows the basic phase-controlling network. A transformer (T) has a center-tapped secondary winding connected to the coupling device. If the center-tap (Y) is used as a zero point, the voltage on one side (X) is, of course, 180° out of phase with the voltage on the other side (Z). Then, if the resistance (R) is high compared with the reactance of the capacitor (C), the coupling device is effectively connected across the upper half of the secondary (XY), and the voltage across it is in equal phase. But if the resistance (R) is low compared with the reactance of the capacitor (C), the coupling device is effectively connected across the lower half of the transformer secondary (YZ), and the voltage across it is now of reversed phase. In this position, the capacitor (C) is connected across the entire winding (XZ), but its reactance is high compared with the reactance of the transformer secondary, and no ill effects are produced. Intermediate values of resistance (R) will cause intermediate phase differences across the coupling device, and will provide the control that is so desirable.
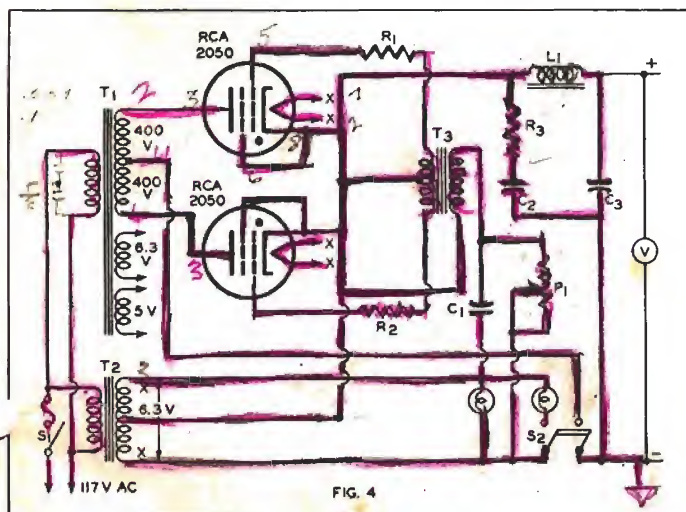
Construction Details

Figure 4 shows the complete circuit of the unit illustrated in the photograph. A separate filament transformer is used to heat the filaments of the RCA-2050's, light the pilot lamps, and supply the phasing voltage. A low-cost, unmounted transformer is used, and is located underneath the chassis. The 6.3- and 5-volt windings on the power transformer are left free and available for heating the filaments of a wide variety of tubes operated from the power supply.

Since a capacitance-input filter is employed, a resistor is used in series with the input capacitor to limit the peak current to the maximum rating. The value of this series resistor is approximately equal to 0.9 ohm per RMS volt of ½ the total secondary voltage of the supply transformer. For an 800-volt center-tapped secondary, the value of the resistor is approximately 800/2 x 0.9, or about 360 ohms.

The 100,000-ohm grid resistors are used to prevent excessive 2050

Operating Precautions

Because a capacitance-input filter is used, the voltage regulation will compare favorably with regular high-vacuum rectifiers. Therefore, the output voltage will rise considerably if the load is removed. The use of a swinging choke at the input to the filter will provide equivalent voltage regulation to standard circuits, but it will also limit the dc output voltage to approximately 90% of the RMS voltage of one-half the high-voltage transformer winding.

The photograph illustrates one satisfactory mechanical arrangement. The electrolytic filter capacitor is mounted directly in back of the 2050 rectifier tubes.

Benefits

All we can say here is that once you have built and used one of these grid-controlled thyratron power supplies, you will wonder how you ever managed to do without it in the past.

THE VERSATILE UNIT READY FOR WORK

It delivers up to 200 Ma at any voltage from 50 to 450 volts.

grid current and consequent loading of the phasing transformer. It may be necessary to reverse the transformer grid connections to get proper phase relation so that firing is prevented when the potentiometer is in a maximum-resistance position.

Don't worry about the 10-uf electrolytic capacitor being used in an ac circuit. Its reactance, or capacitance is practically the same in both directions, and the peak voltage of less than 10 is not high enough to cause it to be damaged.

The phasing transformer is a small-size audio unit, single plate to push-pull grids. It is mounted underneath the chassis in a convenient position.

Two switches are used to cut the unit on and off. S1 puts voltage on all tube heaters, and S2 delivers high voltage to the rectifiers. S2 should never be closed until the 2050 heaters have had a warm-up of at least 10 seconds, and preferably 30 seconds.

Power supply schematic.

PARTS LIST

T1   Power transformer, 800 V., center-tapped secondary, 200 Ma capacity

T2   Filament transformer, 6.3 V., 1.2 amps

T3   Interstage audio transformer, single-plate to P-P grids

C1   10 μf, 150 V., electrolytic

C2 C3   8 μf each, dual electrolytic, 450 V. working

R1, R2   100,000 ohms, ½ watt, carbon

R3   360 ohms (approx.), 25 watt, wire-wound (see text)

P1   10,000 ohm wire-wound potentiometer

L1   Choke, 10 henries (approx.), 200 Ma.

ECHOS

In the September issue of Ham Tips, as well as in the letter-size data sheets which we distributed concerning the new ICAS ratings on the 813, we used poor arithmetic.

In the table under class C Telephony, ICAS, with 2000 volts on the plate, a grid resistor value of 41,250 ohms is shown. The correct value is 11,000 ohms for a grid current of 16 milliamperes.

RCA-2050 THYRATRON

HOT-CATHODE GAS-TETRODE

Amateur Net   **$1.70**

RCA
2050

Features

- *Excellent Efficiency.* SMALL TUBE DROP PERMITS GOOD RECTIFIER VOLTAGE REGULATION.
- *High Sensitivity.* AVERAGE PLATE-GRID CONTROL RATIO IS 250 TO 1.
- *Infinitesimal Grid Drive.* LESS THAN 0.1 MICROAMPERE CURRENT REQUIRED FOR FIRING.
- *Inert-Gas Filled.* EFFECTS OF AMBIENT TEMPERATURE CHANGES ARE NEGLIGIBLE.
- *Optional Mounting Position.* USE OF A HEATER-CATHODE DESIGN TOGETHER WITH AN INERT GAS ALLOW THE TUBE TO BE MOUNTED IN ANY POSITION.
- *Tetrode Construction.* ADJUSTMENT OF SHIELD-GRID VOLTAGE PERMITS CONTROL GRID TO HAVE EITHER NEGATIVE OR POSITIVE CONTROL CHARACTERISTICS.

Application

Rectifier Service. Choke-input filtering is recommended. If capacitance-input filtering is used, sufficient series impedance is required to keep the peak cathode current within rating.

Relay Service. With 60-cycle anode supply the grid regains control at the end of each positive half-cycle of the anode voltage, thereby providing on-off control. The grid can be excited from dc or from ac pulses up to 2 megacycles in frequency.

Bias Service. In low-voltage dc regulator circuits, a few ohms of resistance should be placed in series with any capacitance across the tube. Drop across the tube can be reduced about two volts by connecting the shield grid to the anode.

Photo-Relay Service. The tube will operate directly from a phototube. In this class of service, a grid resistance as high as 10 megohms may be used. The shield grid must be tied to the cathode.

Relaxation Oscillator Service. Shield the tube from rf fields and put rf impedances in series with the elements, otherwise the tube cannot deionize when the plate voltage drops below the sustaining potential.

Inverter Service. RCA-2050's can be used in inverter service at frequencies up to approximately 1000 cycles per second.

Remote Control Service. A number of remote circuits can be independently step-controlled over one pair of wires by using a 2050 at each remote circuit and having each 2050 arranged to operate at a different control-grid voltage.

RCA-2050 THYRATRON — Gas-Tetrode
GENERAL DATA

Electrical:

Heater for Unipotential Cathode
Voltage*	6.3	ac or dc volts
Current	0.6	amp

Direct Interelectrode Capacitances (Approx.) :§
Grid No. 1 to Anode	0.26	μμf
Input	4.2	μμf
Output	3.6	μμf
Tube Voltage Drop	8	volts

Control Ratio at Breakdown (Approx.)
Grid No. 1 to Anode (Grid-No. 2 Voltage = 0)	250
Grid No. 2 to Anode (Grid-No. 1 Voltage = 0)	800

Maximum Ratings, Absolute Values:

Peak Forward Anode Voltage	180 max.	650 max. volts
Peak Inverse Anode Voltage	360 max.	1300 max. volts
Grid-No. 2 (Shield Grid) Voltage		
Before Conduction	—100 max.	—100 max. volts
During Conduction	—10 max.	—10 max. volts
Grid-No. 1 (Control Grid) Voltage		
Before Conduction	—250 max.	—250 max. volts
During Conduction	—10 max.	—10 max. volts
Peak Grid-No. 1-to-Anode Voltage		
(Grid negative with respect to anode)	—	750 max. volts
Peak Cathode Current	1.0 max.	1.0 max. amp.
Average Cathode Current†	200 max.	100 max. ma.
Surge Cathode Current for 0.1 sec. max.	10 max.	10 max. amp.
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	100 max.	100 max. volts
Heater positive with respect to cathode	25 max.	25 max. volts
Ambient Temperature Range	—75 to +90	—75 to +90 °C

Typical Operating Conditions for Relay Service:

RMS Anode Voltage*	400	volts
Grid-No. 2 Voltage	0	volts
RMS Grid-No. 1 Bias Voltage**	5	volts
Peak Grid-No. 1 Signal Voltage	5	volts
Anode Circuit Resistance‡	2000	ohms
Grid-No. 1 Circuit Resistance	1.0	megohm

Maximum Circuit Values:

Grid-No. 1 Circuit Resistance:
For Average anode current of 100 ma. max.	10 megohms
For Average anode current of 200 ma. max.	2 megohms

§Without external shield.

*Heater voltage must not deviate more than 10% from the rated value and must be applied at least 10 seconds before start of conduction.

†Averaged over any 30-second interval.

**Approximately 180° out of phase with the anode voltage.

‡Sufficient resistance, including the tube load, must be used under any conditions of operation to prevent exceeding the current ratings.

NOVEL RIG GIVES TOP NOTCH PERFORMANCE ON 2 METERS

NEW, SMALL "IKE" FOR HAM VIDEO WORK

Amateur television will be given a good "shot in the arm" by this new two-inch diameter camera tube—the RCA-5527 Iconoscope. The equipment required for its operation is relatively simple and inexpensive. Using electrostatic deflection, the "Small Ike" eliminates the need for costly deflection coils and circuits as well as keystoning and shading circuits. It has a resolution capability of approximately 250 lines.

UNDERSTANDING FREQUENCY DOUBLERS AIDS IN EFFICIENT TUBE OPERATION

The phenomena of frequency multiplication is well known, even though it may not be as well understood by some Amateurs. It is safe to say that a Ham station without a doubler is as rare as a ham sandwich without mustard. But are these doublers being operated properly? Are they converting dc plate current into usable rf power, or are they dissipating it in the form of heat? The odds are that real improvements can be made. On this premise RCA engineers went about devising practical data for the guidance of Amateurs to help them select and operate tubes as frequency multipliers.

The Reason Why

Although the mechanics of handling doublers and triplers has now been reduced to a matter of simple arithmetic, an understanding of the basic engineering principles will assist in the solution of the formulas, and at the same time satisfy the Amateurs' natural curiosity and desire for "know-how."

Using a simple analogy, an electron tube frequency multiplier can be compared to a pendulum and its escapement (driving mechanism). The pendulum is the plate tank, and the escapement is the plate-current pulse. Now, if the escapement hits the pendulum once each cycle (360° excursion) the ratio is 1 to 1, and is equivalent to straight-through amplifier action. But if the escapement hits the pendulum once every two or every three cycles, the escapement frequency will be one-half or one-third the oscillation frequency of the pendulum, and the action will be equivalent to an electron tube operating as a doubler or tripler.

A moment of mental juggling with this analogy will make clear that for a given amount of driving

UNIT DEVELOPS SIGNAL EASILY COPIED ON NARROW BAND SUPERHET' CONVERTER

By J. H. Owens, W2FTW

Wobbulated power oscillators and supperregen' swoosh-boxes are rapidly losing their popularity on 2 meters. Coming into favor are crystal-control transmitters and superhet' receivers. The band is going through the same process of evolution that cleaned up the 5-meter band pre-war. Eventually, it may become as thickly populated as the lower frequency bands, and then the need for VFO control will be realized.

Anticipating future needs, a project was opened to develop a medium-power transmitter that would generate a signal capable of being copied on a converter in conjunction with a narrow-band communications superhet'. Ordinarily this could be accomplished quite easily with four or five stages, many tubes, and two or three chassis loaded with wallet-flattening meters, condensers, and other parts. But could it be done the Amateur way—with low-cost tubes and components, together with some Ham ingenuity? The answer is "Yes."

The accompanying photographs show the transmitter which finally met all the Ham specifications set up for it. It is a three-stage job, consisting of a 36-megacycle electron-coupled oscillator which doubles in the plate circuit to 72 Mc, followed by a push-push doubler to 144 Mc, and then a 30 watt, 2-meter final amplifier.

On the same chassis is a modulation transformer, which together with an audio oscillator tube, serves to make the transmitter suitable for MCW code work. The only other electronic component is a voltage-regulator tube which keeps the oscillator screen grid at 150 volts.

The Solution

With the exception of the oscillator coil, all circuits are series tuned. Series tuning was used because it allows the use of low-cost single-section condensers, permits the rotors to be grounded, and suppresses parasitic oscillations. The total capacitance across the tank inductance is reduced, thereby permitting higher values of inductance, lower tank current, and

IT WORKS AS NICE AS IT LOOKS
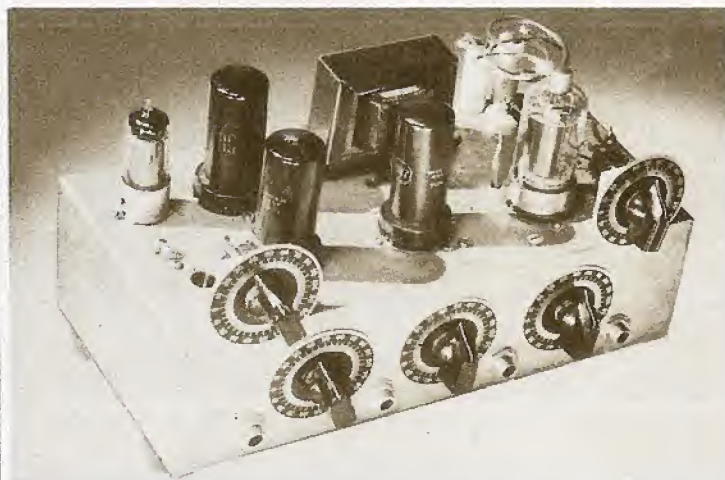
The three-stage medium-power transmitter which is easily constructed with low-cost tubes and components.
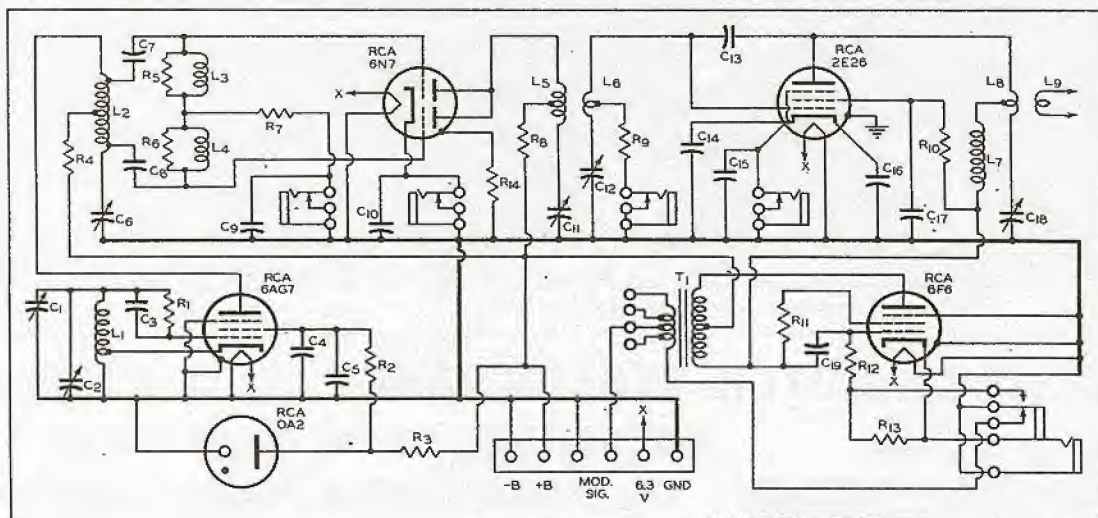
2-meter rig schematic.

2-METER RIG

(Continued from Page 1, Column 4)

higher efficiency. In addition, it provides phase inversion where out-of-phase voltages are required.

Series tuning is *not* series resonance. A series-tuned circuit is properly described as a pi-section filter. A more descriptive expression would be "phantom tube tuning." To see this clearly, consider a regular push-pull plate tank whose resonant frequency is determined by the output capacitances of the two tubes, as well as by other factors. If the output capacitance of either one or both of the tubes could be made variable, it could be used to swing the tank frequency over a useful frequency range. It follows, therefore, that if one tube is removed from the circuit, a variable condenser can be substituted for it to serve as a convenient tuning control. This is series tuning of parallel resonance.

The overall arrangement results in a compact transmitter on a 3" x 5" x 10" bright-plated chassis—a unit that delivers 15 watts of clean 2-meter rf—with a total current drain of less than 175 ma at 400 volts. It is a complete transmitter, requiring only a power supply, a telegraph key, and an antenna. If a 15-watt speech amplifier is connected to it, it becomes a high-quality phone unit.

Circuit Details

The oscillator is conventional enough with the exception of the plate circuit. Series tuning was used to provide the necessary push-pull driving voltage for the 6N7 grids.

The 6N7 doubler is a conventional push-push hook-up except for its series tuned plate circuit. Notice that a metal, not a "GT", tube is used because the former has lower lead inductance. Notice also that the metal shell is *not* grounded directly, but through a 100,000 ohm resistor. This is important, because grounding the shell, or substituting a 6N7-GT will positively lower the output.

The 6N7 plate is electromagnetically coupled to the series-tuned 2E26 grid circuit. It is always good practice to couple in this manner, or through a link, when the tube to be driven requires neutralization.

Obtaining Neutralization

And here is a very interesting angle — neutralization is obtained by adding to the grid-plate-capacitance. The reason for this is that a voltage 180 degrees out-of-phase with the plate to ground voltage is developed across the screen-grid lead inductance. This voltage feeds back to the grid a neutralizing voltage, by way of the grid-to-screen-grid capacitance, which becomes excessive at two meters. So the excess neutralization must be balanced by additional capacitance from the plate to the grid.

In practice, the screen-grid lead inductance should be varied by by-passing the screen-grid to ground at a spot which makes the tube just a little over-neutralized and then balance out this over-neutralization by the addition of a very small amount of external grid-plate capacitance.

Like the other plate circuits, the 2E26 tank is series tuned. The coil is fed through an rf choke at its center where there is very little rf voltage. Inductive wire-wound dropping resistors are used to feed the plate voltage to the other tubes, and serve as rf choke as well as dropping resistors.

The following table gives tube voltages and currents normal for the transmitter:

Tube	6AG7	6N7	2E26	6F6	
Eb	310	250	400	400	volts
Ib	22	22	56	50	ma
Ec2	150	per	200	250	volts
Ic2	6	section	6.5	9	ma
Ec1	−30	−95	−50	−90	volts
Ic1	1.2	3	2.5	3	ma

The 6F6 oscillator is somewhat novel in that the screen grid is connected so that it acts like a control grid, thereby contributing feedback for oscillation. This will give more audio output for a given amount of input than a regular pentode or triode connection. It will deliver enough audio for 70% modulation. If more is desired, plug in a 6L6.

Construction Hints

Perhaps the most important thing to understand is that a cadmium-or

An under-chassis view of the 2-meter rig reveals a symmetrical arrangement of components.

zinc-plated chassis must be used. A black wrinkle enameled chassis simply will not do. Since the rf return from all of the series tuning condensers passes through the chassis, the rf resistance of the chassis must be kept low.

The modulation transformer is a universal output transformer, connected in reverse. It must first be disassembled and some spacing put between the E and I core sections to prevent them from becoming saturated by the 2E26 plate current. The transformer should be cushion-mounted on rubber grommets; otherwise, it may impart enough vibration to the chassis to shake the grid of the 6AG7 and cause some frequency modulation of the carrier.

Tuning Up

Aside from removing the plate supply voltage from the 2E26 screen grid and plate, no other precautions are necessary for tuning up. The full 400 volts can be applied to the oscillator and doubler safely. Adjust the bandspread oscillator trimmer to its midway position and tune the plate condenser for maximum 6N7 grid current. Then, tune the 6N7 plate and 2E26 grid condensers for maximum 2E26 grid current. Check the final frequency and repeat this procedure until the transmitter is inside of the 2-meter band.

The next step is to neutralize the 2E26. Adjust the neutralizing wire until the plate tuning condenser has the minimum effect on the 2E26 grid current. Connect the high voltage to the final, and the transmitter is ready for service.

Experimentation should be made in the degree of coupling between the 6N7 plate and 2E26 grid tank coils. Optimum coupling will provide maximum 2E26 grid current with minimum 6N7 plate current.

PARTS LIST

L1	5 turns #14, ½" ID, 1" lg., cathode tap 1st turn
L2	6 turns #14, ¾" ID, 1½" lg., B+ tap in center
L3, L4	40 inches #30 wire wound around R5 and R6
L5	3 turns #14, ¾" ID, ¾" lg.
L6	2 turns #14, ¾" ID, ¾" lg.
L7	20" #18 wire, ¼" ID, 1" lg.
L8	2 turns, 1½" ID (11" #12 wire)
L9	1-or-2 turn antenna pickup coil
T1	Universal Output Xfmr (air-gap in core)
C1	50 uuf, APC, air padder
C2, C12	35 uuf, variable (HF-35)
C3	100 uuf midget mica
C4, C10	500 uuf midget mica
C5	10 uf, 150 volt electrolytic
C6, C11	15 uuf variable (HF-15)
C7, C8, C9	50 uuf, midget mica
C13	Neutralizing wire see text
C14, C15, C16, C17	500 uuf, midget mica
C18	15 uuf, double spaced (HF-15X)
C19	0.02 uf, 600 volt, paper
R1	24000 ohms, 1 watt, carbon
R2	100 ohms, ½ watt, carbon
R3	10000 ohms, 10 watt, WW
R4	4000 ohms, 10 watt, WW
R5, R6	500000 ohms, 1 watt
R7	30000 ohms, 1 watt, carbon
R8	3000 ohms, 10 watt, WW
R9	20000 ohms, 1 watt, carbon
R10	30000 ohms, 2 watt, carbon
R11	25000 ohms, 10 watt, WW
R12	10000 ohms, 2 watt, carbon
R13	2200 ohms, 2 watt, carbon
R14	100000 ohms, ½ watt, carbon
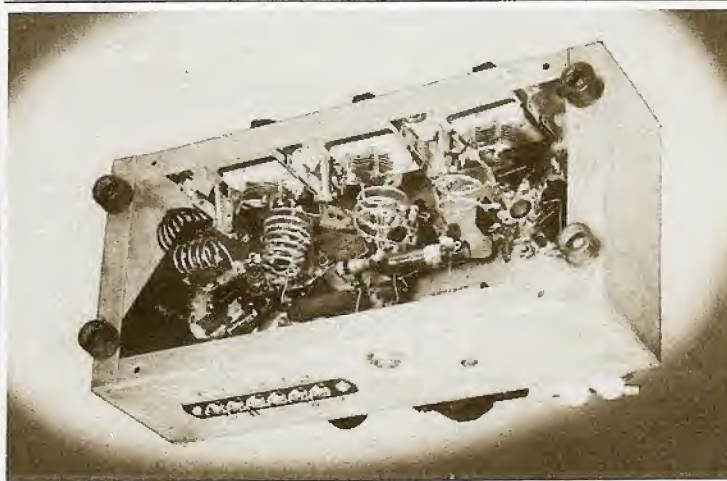
FREQUENCY DOUBLERS

(Continued from Page 1, Column 2)

force, the excursion of the pendulum will become smaller when the harmonic number is increased, simply because the escapement strikes the pendulum less often. Likewise, in an electron-tube circuit, as the harmonic number is increased, the plate-current pulse occurs less often. This means that the plate pulse power must be increased as the harmonic number is increased, if the dc plate input power is to remain unchanged.

Frequency Doubler Action

There are three main factors which limit the performance of frequency multipliers, viz., maximum peak cathode current, maximum negative grid bias, and maximum rated plate dissipation. Inasmuch as tubes are rated near their limits for amplifier service, and since the efficiency of frequency multipliers is generally less than that of amplifiers, multiplier applications will usually allow less plate power input. Otherwise, tube ratings will be exceeded.

Figure I shows graphically the action in a frequency doubler. The relationships illustrated are, of necessity, approximations, but they paint a representative picture of what occurs. For instance, it is shown that the plate current pulse occurs between the point of cutoff bias and the most positive excursion of the grid. This indicates that the correct bias voltage is not only a function of the mu-factor of the tube but that it is determined by the combined effects of cutoff voltage and peak positive grid voltage.

The function of high grid bias is to shape the plate-current pulse so that it approximates the shape of a half cycle of a wave of twice the grid-signal frequency. Note that the plate-current pulse (X) has the same width as the grid-voltage wave (X') during the period of plate-current conduction. Note also that two complete oscillations occur in the plate circuit for each grid circuit cycle (2F'=F). It can be seen, therefore, that the grid circuit and plate circuit are synchronized. The lower-frequency grid voltage oscillates in perfect 1-to-2 timing in relation to the higher frequency ac plate voltage, and periodically produces pulses of plate current at exactly the right instant, every other plate-voltage cycle, to keep the plate circuit oscillating. For purposes of illustration, the drawing shows that plate current flows for exactly one-quarter of a grid-voltage cycle. Actually, this 90° conduction period may vary from 80° to 140° and still give excellent results. The grid-bias formulas given in Table I are based on a conduction angle of 120° for doubler operation. For triplers, a 100° conduction angle was used and for quadruplers the angle chosen was 80°.

Performance Limitations and Efficiency

Optimum multiplier efficiency is a compromise. Although it is possible to obtain the same plate-circuit efficiency in a multiplier stage as is attainable in a "straight through" amplifier stage, limitations in the peak cathode current available and in the maximum grid-bias ratings of the tube reduce the output power to a fraction of that attainable by operating the tube with less plate circuit efficiency.

Furthermore, high-efficiency multiplier operation requires increased driving power, which results in low power gain per stage. The efficiencies shown in Table I are, therefore, compromise efficiencies. Even with recommended multiplier efficiency, the power gain is less than that of an amplifier, and the driving power requirements are considerably higher.
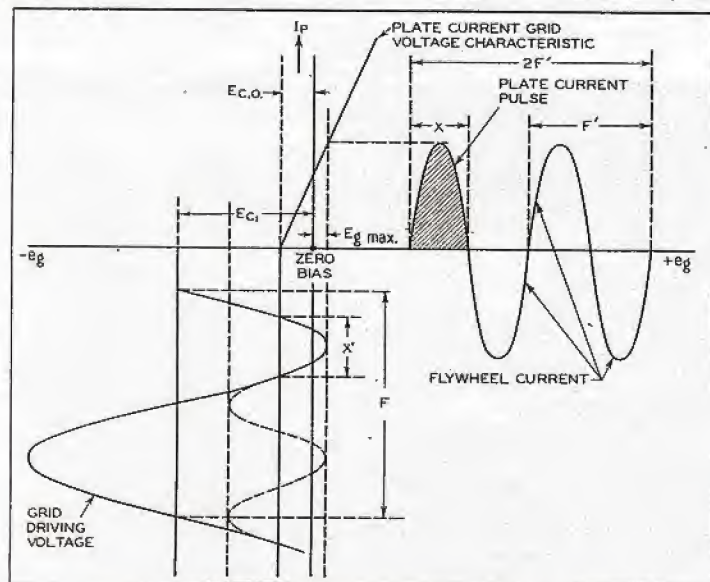
Frequency Multiplier Factors	Doubler Service	Tripler Service	Quadrupler Service
Power input ratio of input rating to plate dissipation rating (approx.)	2 to 1	1.6 to 1	1.4 to 1
Beam tube or pentode grid bias	2 Eco + 0.8 Eg max.	3 Eco + 1.5 Eg max.	4.5 Eco + 3 Eg max.
Triode grid bias	3 Eco + 0.8 Eg max.	5 Eco + 1.5 Eg max.	8 Eco + 3 Eg max.
Optimum efficiency for max. output	50%	38%	28%
Power output ratio of output to plate dissipation (approx.)	1 to 1	0.6 to 1	0.4 to 1

Table I

Preferred Tubes

The great number of limitations and compromise factors suggest that all tubes are not good frequency multipliers. A satisfactory triode type is one that has a combination of high mu and a high-wattage filament. The 808, 826, 839, and 811 make an excellent group.

Beam tubes and pentodes, because of their extremely high grid-plate amplification factor, are naturally good multipliers, but some are better than others. High-wattage filaments (or heater cathodes) and high transconductance are two prime quality factors. In the transmitting power class, the 2E26 and 807 are preferred types, with the 815 and 829-B taking the lead for tripler service.

Application Considerations

Probably the best way to become acquainted with the use of Table I is to work out an illustrative example. Regular ICAS Class C telegraphy data is also needed, and inasmuch as the 2E26 is featured on page 4 of this issue of HAM TIPS, it will serve as the number-one guinea pig. Using maximum ratings and typical operating conditions, take the following steps to determine optimum data for doubler service.

(1) To determine the maximum power input, multiply the plate dissipation by the power input ratio: as shown in Table I.
$$13.5 \times 2 = 27 \text{ watts} = \text{Pin}$$
(2) To determine the maximum plate current, divide the power input by the chosen plate voltage:
$$27 \div 600 = 45 \text{ ma} = \text{Ib}$$
(3) To determine the cutoff bias, divide the chosen screen voltage by the grid-to-screen mu-factor:
$$185 \div 6.5 = -28 \text{ volts} = \text{Eco}$$
(4) To determine the peak positive grid voltage, subtract the Class C telegraphy dc grid bias from the peak rf grid voltage:
$$57 - 45 = 12 \text{ volts} = \text{Eg max.}$$
(5) To determine the grid bias, multiply the cutoff bias by 2; multiply the peak positive grid voltage by 0.8, and add their products:
$$(2 \times 28) + (0.8 \times 12) = -66 \text{ Ecl}$$
These values are given in the line labeled doubler service for pentodes or beam tubes in Table I.
(6) a. To determine the expected power output, multiply the power input by the optimum efficiency:
$$27 \times 0.50 = 13.5 \text{ watts} = \text{Po}$$
(6) b. The power output can also be estimated by multiplying the plate dissipation by the power ratio of output to plate dissipation:
$$13.5 \times 1 = 13.5 \text{ watts} = \text{Po}$$
The procedure is the same for triodes except that the grid-to-plate mu factor is used instead of the grid-to-screen mu factor. It will be seen that triodes require a larger cutoff voltage multiplier than screen-grid tubes. The reason is that the value of cut-off bias varies with the instantaneous plate voltage. For practical multiplier operation, the effect of this variation is to increase the required grid bias. In screen-grid tubes the cut-off bias is not a function of the plate voltage and, therefore, this effect is not present.

Parallel, Push-Pull, and Push-Push Operation

When more power is needed than a single tube will deliver, and a tube of the right size and proper characteristics is not available, two tubes may be used. If the tubes are connected in parallel, the operation will be essentially the same as for a single tube, except that the power output will be doubled, and the input and output capacitances will be doubled.

Push-pull operation is not so simple. It suppresses even-order harmonics and accentuates the odd ones; therefore, it is used in tripler and quintupler circuits. As compared with the parallel connection, the input and output capacitances are halved instead of doubled—an important advantage at very high frequencies.

Push-push (push-pull grids and parallel plates) is exactly the opposite of push-pull in that the even harmonics are accentuated and the odd multiples suppressed. It is used for doubler and quadrupler service, and can be expected to give somewhat higher power gain than parallel operation. Because the plate circuit receives twice as many pulses as a single-ended doubler, decrement losses are minimized; I^2R losses are reduced because some circuit components are required to carry only one-half the peak current normal to a regular doubler.

ECHOS

The "Super-Slugger" article which appeared in the September issue of Ham Tips referred to a pair of National TMA-100-DA split-stator variable condensers. Actually, the condensers used in the unit's construction were the TMA-50-DA type.

Figure I. Graphic illustration of frequency doubler action.

V-H-F BEAM POWER AMPLIFIER

35 WATTS at 2 Meters

Amateur Net **$3.50**

RCA 2E26

Features

- *Small size.* For compact transmitters and efficient VHF mechanical designs.
- *Low lead inductance.* Short internal leads keep tube easy to drive at VHF.
- *Shielding.* Internal and external shielding provides exceptional circuit stability.
- *High power gain.* Minimizes number of buffer-amplifier stages required.
- *Versatility.* Excellent crystal oscillator, frequency multiplier, ECO, or amplifier.
- *VHF design.* Permits full input to 125 megacycles, and 83% of full input to 150 megacycles.
- *Micanol base.* High-frequency, mica-filled phenolic type. For use with low-cost octal sockets.

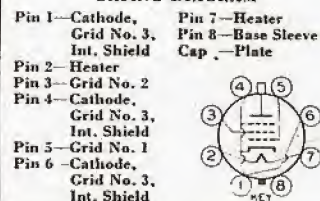## Application

- *Plate Modulation.* Modulate screen grid simultaneously with plate by feeding through dropping resistor from modulation transformer. Do not bypass the screen grid for audio frequencies—500 uuf to 5000 uuf is ample for VHF or HF service.

- *Overloading.* Do not allow the plate or screen grid to show color as this is proof that tube dissipation is in excess of maximum ratings.

- *Grounding.* All three cathode socket terminals must be grounded directly or through individual mica bypass capacitors of 500 uuf to 5000 uuf each.

- *Feedback.* The small residual grid-plate capacitance will allow the tube to operate without neutralization in the region between 75 and 10 meters.

- *Grid Driver.* Almost any small receiving tube will do the job in HF service. At 2 meters, more drive is required, and a 6N7 push-push doubler is recommended.

- *Shielding.* The high power gain of the tube necessitates complete isolation of the grid and plate circuits. A good technique is to keep the grid tank under the chassis and the plate tank on top of the chassis.

- *Stabilization.* In HF service between 3 and 30 Mc, where grid-driving requirements are extremely low, a few ohms of resistance directly in series with the grid will make the circuit extra stable and will not impair the plate efficiency.

- *VHF Service.* At 6 and 2 meters, neutralization may be required. In some mechanical arrangements, the tube will be over-neutralized—then it may be necessary to *add* a small amount of grid-plate capacitance.

BASING DIAGRAM

Pin 1—Cathode,
    Grid No. 3,   Pin 7—Heater
    Int. Shield   Pin 8—Base Sleeve
Pin 2— Heater   Cap .—Plate
Pin 3—Grid No. 2
Pin 4—Cathode,
    Grid No. 3,
    Int. Shield
Pin 5—Grid No. 1
Pin 6 —Cathode,
    Grid No. 3,
    Int. Shield

CHARACTERISTICS AND RATINGS

GENERAL DATA

Heater, for Unipotential Cathode:

Voltage	6.3	ac or dc volts
Current	0.8	amp.

Transconductance
for plate current of 20 ma.   3500 μmhos
Grid-Screen Mu-Factor   6.5
Direct Interelectrode Capacitances:*

Grid to plate	0.20 max.	$\mu\mu$f
Input	13	$\mu\mu$f
Output	7	$\mu\mu$f

PEAK HEATER-CATHODE VOLTAGE:

	CCS	ICAS
Heater negative with respect to cathode	100 max.	100 max. volts
Heater positive with respect to cathode	100 max.	100 max. volts
Mounting Position		Any

Maximum Circuit Values:
Grid-No. 1-Circuit Resistance ....30000 max.   30000 max. ohms

PLATE-MODULATED RF POWER AMPLIFIER—Class C Telephony
Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, *Absolute Values:*

	CCS	ICAS
DC PLATE VOLTAGE	400 max.	500 max. volts
DC GRID-No. 2 (SCREEN) VOLTAGE	200 max.	200 max. volts
DC GRID-No. 1 (CONTROL GRID) VOLTAGE	—175 max.	—175 max. volts
DC PLATE CURRENT	60 max.	60 max. ma.

HAM TIPS is published by the RCA Tube Department, Harrison, N. J., and is made available to Amateurs and Radio Experimenters through RCA tube and parts distributors.

H. S. STAMM .... Editor
J. H. OWENS .... Technical Editor

	CCS	ICAS
DC GRID-No. 1 CURRENT	3.5 max.	3.5 max. ma.
PLATE INPUT	20 max.	27 max. watts
GRID-No. 2 INPUT	1.7 max.	2.3 max. watts
PLATE DISSIPATION	6.7 max.	9 max. watts

Typical Operation:

		CCS	ICAS	
DC Plate Voltage		400	500	volts
DC Grid-No. 2 Voltage†	{	160	180	volts
		32000	35500	ohms
DC Grid-No. 1 Voltage	{	—50	—50	volts
		20000	20000	ohms
Peak RF Grid-No. 1 Voltage		60	60	volts
DC Plate Current		50	54	ma.
DC Grid-No. 2 Current		7.5	9	ma.
DC Grid-No. 1 Current (Approx.)		2.5	2.5	ma.
Driving Power (Approx.)		0.15	0.15	watt
Power Output (Approx.)		13.5	18	watts

RF POWER AMPLIFIER & OSCILLATOR—Class C Telegraphy

Maximum Ratings, *Absolute Values:*

DC PLATE VOLTAGE	500 max.	600 max. volts
DC GRID-No. 2 (SCREEN) VOLTAGE	200 max.	200 max. volts
DC GRID-No. 1 (CONTROL GRID) VOLTAGE	—175 max.	—175 max. volts
DC PLATE CURRENT	75 max.	75 max. ma.
DC GRID-No. 1 CURRENT	3.5 max.	3.5 max. ma.
PLATE INPUT	30 max.	40 max. watts
GRID-No. 2 INPUT	2.5 max.	2.5 max. watts
PLATE DISSIPATION	10 max.	13.5 max. watts

Typical Operation:

DC Plate Voltage	400	500	600	volts
DC Grid-No. 2 Voltage§ {	190	185	185	volts
	19000	28500	41500	ohms
DC Grid-No. 1 Voltage‡ {	—30	—40	—45	volts
	10000	13500	15000	ohms
Peak RF Grid-No. 1 Voltage	41	50	57	volts
DC Plate Current	75	60	66	ma.
DC Grid-No. 2 Current	11	11	10	ma.
DC Grid-No. 1 Current (Approx.)	3	3	3	ma.
Driving Power (Approx.)	0.12	0.15	0.17	watt
Power Output (Approx.)	20	20	27	watts

*With no external shielding, and with base sleeve connected to ground.

†Obtained preferably from a separate source modulated with the plate supply, or from the modulated plate-supply through a series resistor of the value shown.

§Obtained preferably from a separate source, or from the plate-voltage supply with a voltage-divider, or through a series resistor of the value shown. The grid-No. 2 voltage must not exceed 600 volts under key-up conditions.

‡Obtained from fixed supply or by grid-No. 1 resistor of value shown.

807's VERSATILE IN RF SERVICE AND CLASS B MODULATION

THE RIG WITH DECKS CLEARED FOR ACTION
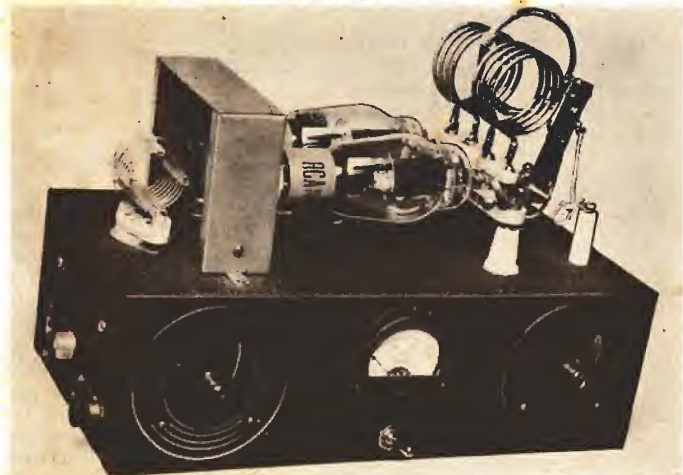
Those 807's mounted in "torpedo" fashion are one good reason this fine looking transmitter has no fear of parasitics.

NEW MODULATOR CIRCUIT UTILIZES 807's IN CLASS B WITH ZERO BIAS

A. M. SEYBOLD, W2RYI

During the intervening years since its development by RCA back in 1936, the 807 has become the Amateurs' number one favorite rf transmitting tube. However, comparatively little use has been made of its excellent class AB₂ characteristics in af modulator service, perhaps because of the difficulties encountered in providing the required regulation of control-grid bias and screen-grid voltages.

In order to avoid these difficulties, the possibility of using this tube as a zero-bias triode in class B audio service was intriguing. Its low price, its small size, and its ability to deliver a great deal of power at low plate voltage provided the impetus for a series of experiments.

The first idea was to tie the control grid and the screen grid together in a manner similar to the way the old type 46 was operated in zero-bias class B service. This produced a low-perveance triode with a plate family of curves that looked like the receding hair line of the Java Ape Man. It would be no brain wave to operate on such a plate family either, for distortion is high and efficiency low.

Another idea was to ground the control grids and put the driving signal on the screen grids at zerobias. This arrangement produced a good plate family, but required ex-

cessive driving voltage for satisfactory power output. Several other schemes were tested with varying results— and then it happened!

One-hundred and twenty watts of audio—with less than six watts of driving power—at only 750 plate volts. And from two tubes which cost only $4.60! What's more, it's very simple. Just connect the cathodes to ground, put the driver transformer between the screen grids, and ground the center tap. Then, connect the control grid of each tube to its screen grid through a 20,000-ohm resistor. That's all there is to it.

During the development of this circuit, plate families were taken with various values of resistance between the #2 grid and the #1 grid. The series of curves shown in Fig. 4 illustrate the effect of the resistance in the #1 grid circuit upon the

TORPEDO TWINS IN 150 WATT FINAL
WORKS ALL BANDS FROM 3 TO 30 MC.

By J. H. OWENS, W2FTW

One-hundred-and-fifty watts input to a cw final with a plate supply of only 750 volts! All-band coverage in the HF region from 3 to 30 Mc, with plug-in coils! Complete freedom from parasitics, without neutralization! And less than two watts of grid-driving power easily obtainable from a 6V6-GT doubler! It's readily possible with a pair of RCA-807's.

Fig. 1a illustrates the usual layout for 807's. Little wonder that it causes so much difficulty when the three prominent feed-back paths are recognized and understood. As the arrows show, direct electrostatic coupling exists between the grid and plate circuits, (1) from the plate tank coil to the grid lead inside of the tube stem, (2) from the plate electrode to the grid tank coil, and (3) from the plate tank condenser to the grid tank condenser. The heavy dashed lines indicate the shielding required to eliminate these sources of stray coupling.

The Torpedo Attack

Fig. 1b shows a preferred mechanical layout for the 807's. Because the tube is mounted horizontally, "torpedo" fashion, it is naturally more stable than it would be in a conventional arrangement because of space isolation alone. The tube socket is mounted through a metal plate which acts as a shield against electrostatic and electromagnetic forces above the chassis.

The plate coil is mounted as illustrated at right angles to the grid coil. A tube shield is not necessary.

Under the chassis, the grid and plate tank condensers are mounted with their rotor sides face to face. This arrangement, plus the greater distance of separation, usually provides sufficient isolation. For additional isolation, however, a shield, transformer, capacitor, or some other metal-cased component can be installed in the space indicated by the dashed line. External feedback is thus reduced to a minimum.

Beam Tubes Versus Triodes

Usually unwanted oscillations in electron tube apparatus result from interaction between the input and output circuits. The tendency toward instability depends on the degree of coupling and the gridplate power gain. If there is zero coupling, there can be no feedback oscillation. Likewise, if there is zero power gain, there can be no oscillation. In a practical circuit, the degree of coupling and the

A DOWN-UNDER VIEW OF THE FINAL
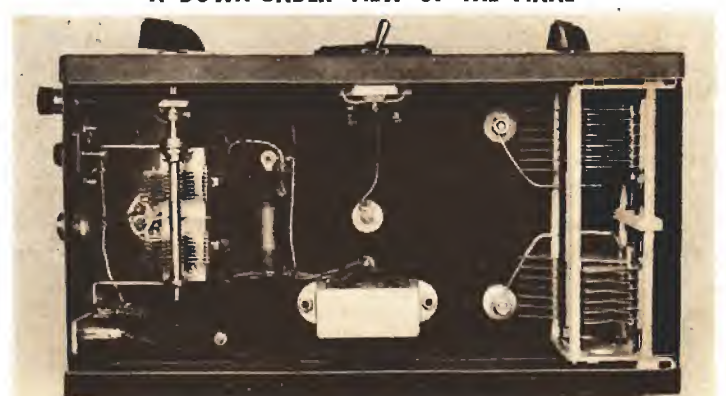
The mechanical arrangement of components contributes to its highly stable operation.

Fig. 1a. This customary layout for the 807 tube may result in feedback difficulties.

Fig. 1b. A preferred mechanical layout for the same tube which reduces feedback to a minimum.

TORPEDO TWINS

(Continued from Page 1, Column 4)

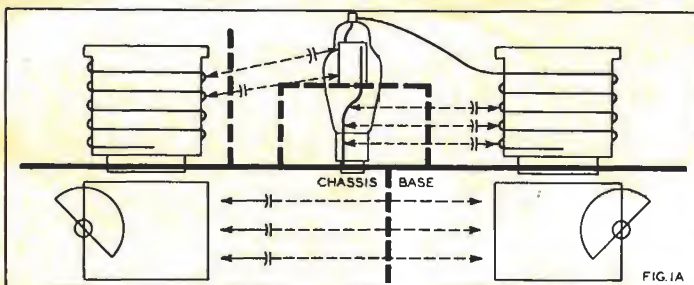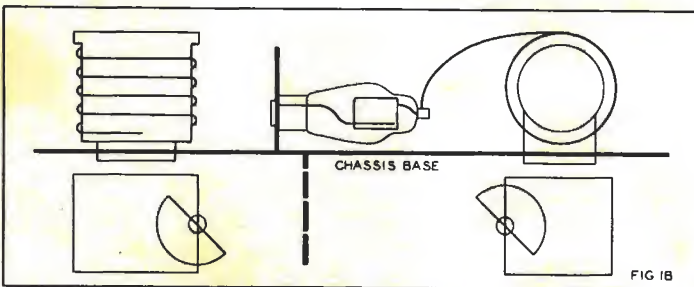grid-plate power gain are positive factors, and oscillations are therefore possible whenever the feedback path is capable of transferring driving power to the grid.

In comparison with a beam tube, a triode having a power gain of only twenty is quite easy to stabilize. Since the power gain is relatively low, satisfactory operation may be expected even though neutralization and grid-plate isolation are imperfect.

However, a beam tube such as the 807, having a power gain of approximately 250, requires more careful handling. The plate has only to "breathe" on the grid to make the circuits oscillate. However, if the power gain of the beam tube is lowered to the level of the triode, it is more easily stabilized than the latter because of its internal shielding. It follows, then, that beam tubes are more stable than triodes when operated under identical performance conditions.

Parasitics

Parasitics are less likely to occur in equipment using old-type low-gain triodes; that is, tubes that have a power gain of less than ten or tubes that have wide electrode spacings and heavy electron transit-time loading. Parasitics will be found, however, in modern equipment using modern tubes, triodes included.

Although parasitics are invisible, they furnish plenty of evidence of their presence. They are the commonest cause of plate tank condenser flash-overs. They heat plate and grid terminal caps. They prevent a pronounced dip in plate current when the unloaded tank circuit is tuned through resonance. They keep the plate efficiency low, and they are responsible for much modulation splatter and BCI.

If a circuit is free of parasitics, the tube will act like a pure resist-

ance when excitation is removed. With full plate (and screen) voltage applied and with the plate tank unloaded, the grid current should drop to zero. Under such conditions, it should not be possible to light a neon bulb at the plate. In making such a test, it is essential to drop the plate voltage so that the rated plate dissipation is not exceeded.

LFP's, NFP's, HFP's?

There are three common forms of parasitics, LFP's, NFP's, and HFP's. LFP's are parasitics lower in frequency than the operating frequency. NFP's are parasitics that are simply self-oscillations at the normal operating frequency. HFP's are parasitics higher than the operating frequency.

LFP's are encountered in electron tube amplifiers having rf chokes in

both the grid and plate circuits. When these chokes resonate, low-frequency parasitics can be generated in tuned-grid, tuned-plate fashion. They can be suppressed by removal of either choke or by the use of a plate choke having a different resonant frequency than the grid choke. NFP's, commonly spoken of as "regeneration", and HFP's, also a common type of parasitic, are not so easily eliminated.

RF Degeneration

Although degeneration is known to benefit audio systems, little consideration has been given to it for rf work. Yet its benefits can be essentially the same. It helps reduce the percentage of undesired harmonics and the trouble they cause when radiated. Moreover, when properly employed, it positively eliminates feedback parasitics.

Parasitic suppression through degeneration should be regarded as a desirable design practice rather than as an expedient for parasitic correction. It costs so little—just a slight increase in driving-power requirements. And the mechanics

Fig. 2a. Parasitics are encouraged in this rf amplifier circuit arrangement.

Fig. 2b. The same circuit after it has been stabilized by degeneration.

are so simple—just a few ohms of resistance in the proper places.

Fig. 2a shows a few of the inductive and capacitive elements that may cause parasitics in a typical rf amplifier. HFP's are quite likely to be found in such an amplifier because at the frequency where the parasitic elements resonate, the regular tuning condensers C_1 and C_2 act like bypass condensers and provide a return path for the parasitic currents.

Fig. 2b shows the same circuit after it has been stabilized by degeneration. A parasitic suppressor, PS_2 is located in the grid circuit where dc and normal-frequency rf currents are small, but where HFP currents would be large. It reduces the circuit power gain just a little but kills HFP's and NFP's which result from capacitive feedback from the plate.

PS_3 is connected to provide simple cathode circuit degeneration. It lowers the power gain slightly but compensates by reducing harmonic generation. Parasitic element PL_3 has been left undisturbed because without a cooperating element in the grid or cathode circuit it can do little harm.

Non-inductive carbon resistors are favored over parasitic chokes because the chokes simply shift the resonant frequency of the parasitic circuits. While this expedient may be very effective for a fixed frequency transmitter, it is not the answer to a multi-band Amateur unit.

Other Stabilizing Stunts

A very effective way of suppressing NFP's is to place a small load across the grid tank circuit. A carbon resistor (PS_1) having a value of something between 5000 and 50,000 ohms will really get results with an insertion loss of only a fraction of a watt. The resistor simply limits the impedance of the grid tank so that minute currents fed back from the plate cannot develop excessive grid voltages which react to cause greater plate-current fluctuations and eventually self-oscillations.

If the 807 is loaded to less than the maximum rated plate current of 100 milliamperes, the screen-grid
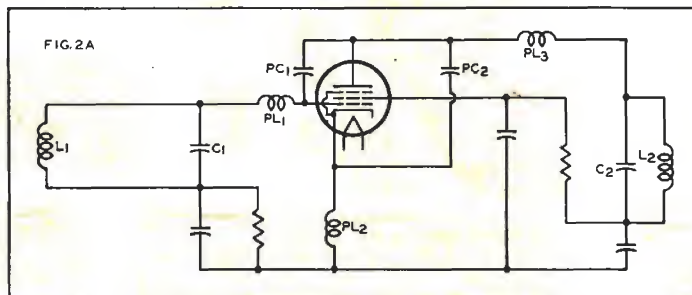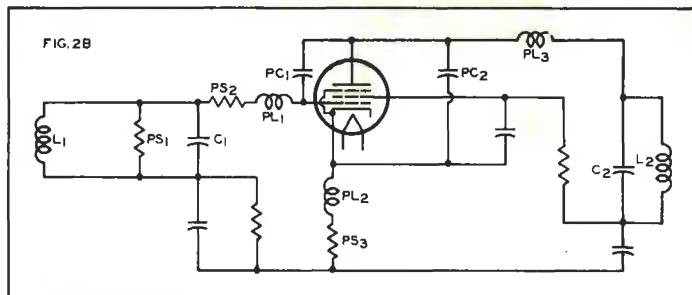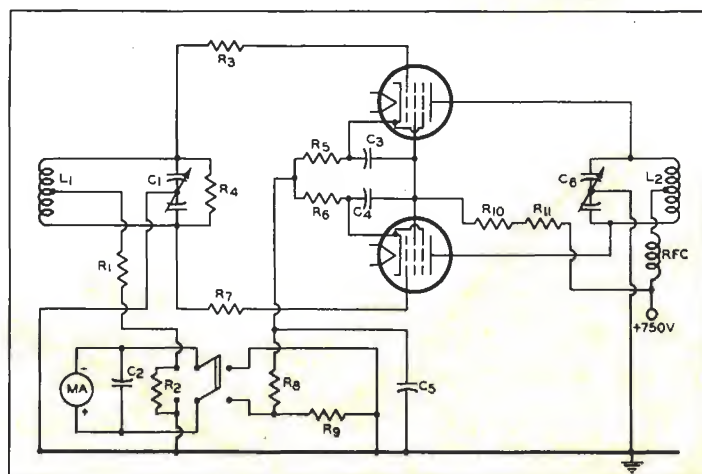
Fig. 3. Schematic of the 150-watt final amplifier using a pair of 807's.

CLASS B MODULATOR

(Continued from Page 1, Column 2)

shape of the diode line. The driving voltage designated Ec is that which is applied directly to the #2 grid. Low values of resistance give poor knees, but as the resistance is increased, the knees improve, until the optimum condition is reached at about 20,000 ohms.

With this value, it can be seen from Fig. 5 that a satisfactory plate family is produced. Grid-current curves for the new zero bias connection are shown as dotted lines, and plate load lines are shown for
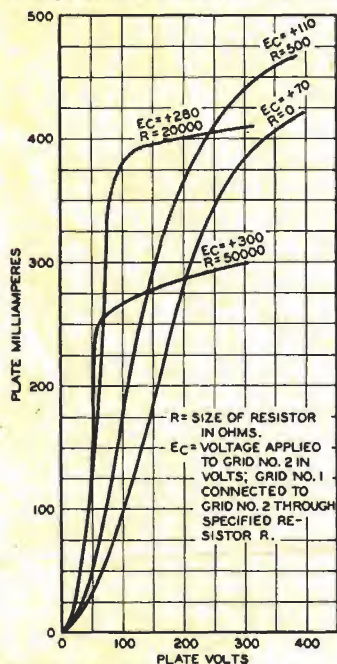
Fig. 4. Effect of the resistor in the #1 grid circuit upon EB vs IB characteristics.
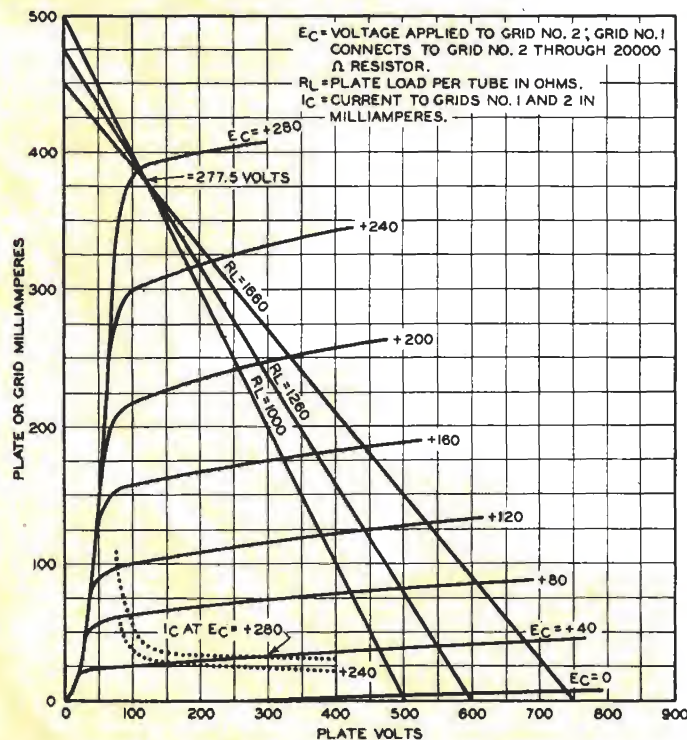
Fig. 5. The 807 plate family with a 20,000 ohm resistor in the #1 grid circuit.

three operating voltages. With a 750-volt supply, a plate-to-plate load of 6600 ohms, and a driving source giving 555 peak volts grid-to-grid, 120 watts of audio are available. The power to drive the grids is greater than that needed for class AB₂, but this is no hardship because a push-pull triode driver will easily furnish the 5.3 watts needed. Fig. 6 shows the circuit for driver and output stages used in the tests at W2RYI.

The only important technical difference between zero bias 807's and regular zero-bias class B triodes is in the values of positive grid impedance. Whereas most of the high-mu zero-bias triodes require low-voltage high-current driving signals, the 807's take excitation at high voltage but with low current.

Computations for driver tubes and transformer ratios for the new method of operation are not difficult to make. The 807's present to the driver a fairly constant load applied continuously, so the computations are just a matter of matching impedances. First, it is necessary to select the driver tubes and establish a set of conditions for them that will provide at least 20% more output than that required to drive the modulator tubes. For example, use a pair of 2A3's, which will give ten watts with a plate-to-plate load of 5000 ohms. The equivalent grid resistance of an 807 operated class B is 7100 ohms, so the driver transformer impedance ratio will be about a 1 to 1.4 step-up between total primary and one-half secondary (Impedance ratio = 7100 ÷ 5000). This is equivalent to a turns ratio of 1 to approximately 1.2, because the turns ratio is equal to the square root of the impedance ratio (1.18 = √1.4).
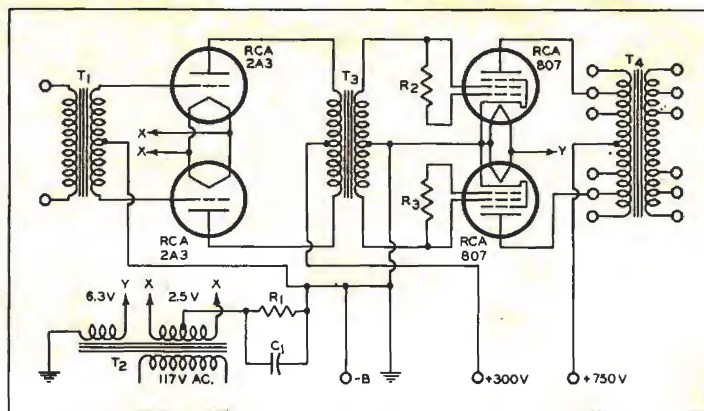
Fig. 6. Schematic for driver and output stages used in the tests at W2RYI.

If your driver transformer doesn't have the required turns ratio in the forward direction, it may be correct when reversed, i.e., with the primary used as the secondary. If this expedient does not work, it will be necessary to get a new driver transformer or a matching transformer to work in conjunction with the one you have. If you use a public address amplifier for a driver, one solution is to use a low-cost universal output transformer rated at 6 watts or more as a matching transformer. With its primary connected to the grids of the push-pull 807's, its secondary (used as a primary) will match a wide range of output impedances such as are common to most PA amplifiers.

RCA-807's, used as zero-bias class B modulators, will furnish enough high-quality audio to fully modulate a quarter-kilowatt transmitter!

PARTS LIST

T1	Input audio transformer
T2	Filament transformer
T3	Driver transformer
T4	Modulation transformer
R1	780 ohms, 10 watts, wire wound
R2, R3	20,000 ohms, 1 watt, carbon
C1	16 or 20 uf, 100 volt, electrolytic

TORPEDO TWINS

(Continued from Page 2, Column 4)

voltage can be reduced proportionately. The effect is an increase in stability resulting from the reduction in transconductance. The difference in power gain is so small that it is negligible.

Still another way to make the 807 meek and obedient if trouble is experienced is to let the driver tube give the grid all of the driving power it can handle. Then, the feedback power becomes small and ineffective by comparison. The procedure is to increase the bias over typical operating values and run the grid current up near maximum ratings.

A further recommended design practice is the use of a small amount of cathode bias or fixed bias. This precaution keeps the transconductance within reasonable limits and protects the tubes and other components during periods of momentary overload when excitation is lost or the plate circuit detuned.

The Torpedo Twin

The photograph and circuit diagram in Fig. 3 illustrate how a pair of 807's might be used in a 150-watt final amplifier. The same mechanical arrangement could be used on a larger chassis of a relay rack panel to provide space for a crystal oscillator and power-supply components. The circuit works all bands from 75 to 10 meters. The coils can be purchased units or they can be home-wound according to Amateur Handbook directions.

The meter arrangement is made by first removing the internal shunt from a 0-300 milliammeter. The shunt is then installed externally across one side of the DPDT toggle switch. Next, another shunt is made from a small piece of resistance wire which will make the meter read 0-30 ma. This shunt is placed across the other side of the toggle switch. A second meter, of course, is needed to calibrate the new shunt. In one position, the meter reads grid current, and in the other position it reads total cathode space current.

The foregoing arrangement is shown only for illustration. The important fact is that degeneration can be used to stabilize 807's. The effectiveness of the system is shown by the fact that the tank condenser does not flash over even when 200% modulation is applied together with other maximum rated voltages.

PARTS LIST

R1	5000 ohms ½ watt, carbon
R2	Homemade shunt (see text)
R3, R7	50 ohms (or less) ½ watt, carbon
R4	10000 to 100000 ohms 1 watt, carbon (see text)
R5, R6	25 ohms (or less) ½ watt, carbon
R8	200 ohms, 10 watt, wire wound
R9	Resistor shunt taken from meter
R10, R11	2—6000 ohms 10 watt, wire wound in series
C1	100 uuf variable, each section, Hammarlund MCD-100S
C2	500 uuf midget mica
C3, C4, C5	0.002 uf postage stamp, mica
C6	100 uuf each section, variable, 0.077" spacing, National TMC-100D
RFC	2 mh rf choke
L1, L2	See text

RCA-807 BEAM POWER AMPLIFIER

75 WATTS INPUT TO 60 MC.

Amateur Net **$2.30**

Features

- *High Perveance.* Takes 40 watts input at 400 volts, or 75 watts at 750 volts.
- *Power Gain.* A 6V6-GT tritet crystal oscillator quadrupler will drive it.
- *No neutralization.* Provides quick band change from 3 to 60 Mc.
- *Real Value.* Thirty-two-plus watts of power input per dollar.
- *Versatility.* Useful in class A, AB₁, AB₂, B, and C services for af and rf.
- *Unipotential Cathode.* Negligible hum. Requires no balancing circuit.
- *Xtal oscillator or ECO.* Will quadruple in the plate circuit and drive two 807's at 30 Mc.
- *AF Modulator.* Two 807's triode-connected, in class B will voice-modulate a quarter KW transmitter.

Application Recommendations

Follow these recommended design practices in stabilizing your transmitter:

1. Bypass the screen grid to the cathode with a mica capacitor of not less than 0.002 uf. Use short leads.

2. Install an unbypassed carbon resistor of 25 ohms or less in the cathode-return circuit.

3. Install a carbon resistor of 50 ohms or less in the connection between the grid tank and the control-grid terminal.

4. Reduce the screen-grid voltage proportionally when the tube is operated at less than 100 ma plate current.

5. Overdrive the tube if stability is a problem. Increase grid current and grid bias but do not exceed maximum ratings.

6. Load the grid tank with a carbon resistor of something between 5000 and 50000 ohms.

7. Make sure that the grid and plate circuits are shielded against electrostatic and electromagnetic coupling.

807 TRANSMITTING BEAM POWER AMPLIFIER

Heater for Unipotential Cathode:

Voltage	6.3 ac or dc volts
Current	0.9 amp.
Grid-Screen Mu-Factor	8.

Direct Interelectrode Capacitances:

Grid to Plate (With External shield)	0.2 max.	$\mu\mu f$
Input	11	$\mu\mu f$
Output	7	$\mu\mu f$

A-F POWER AMPLIFIER AND MODULATOR CLASS B

Two tubes. Push-pull triode connection. Input to each grid No. 2. Grid No. 1 connected to grid No. 2 through 20,000-ohm resistor.

DC Plate Voltage	500	600	750	volts
DC Grid Voltage	0	0	0	volts
Peak AF Grid-to-Grid Voltage	555	555	555	volts
Equiv. Grid Resistance (1 tube)	7100	7100	7100	ohms
Zero-Signal DC Plate Current	6	10	15	ma.
Max.-Signal DC Plate Current	240	240	240	ma.
Max.-Signal DC Grid Current	25	25	25	ma.
Effective Load Resistance (plate to plate)	4000	5050	6650	ohms
Max.-Signal Driving Power	5.3	5.3	5.3	watts
Max.-Signal Power Output	72	91	120	watts

PLATE-MODULATED RF POWER AMPLIFIER—Class C Telephony

Beam tube connection. Carrier conditions per tube for use with max. modulation factor of 1.0.

DC Plate Voltage	325	400	475	600	volts
DC Grid-No. 2 Voltage***	225	225	225	275	volts
	20000	30000	50000	50000	ohms

DC Grid-No. 1 Voltage**‡	—75	—80	—85	—90 volts
Grid Current bias resistor	25000	22800	21300	22500 ohms
Peak RF Grid No. 1 Voltage	90	95	110	115 volts
DC Plate Current	80	80	83	100 ma.
DC Grid-No. 2 Current	5	5.75	5	6.5 ma.
DC Grid-No. 1 Current (Approx.)	3	3.5	4	4 ma.
Driving Power (Approx.)	0.25	0.3	0.4	0.4 watt
Power Output (Approx.)	17.5	22.5	27.5	42.5 watts

RF AMPLIFIER AND OSCILLATOR—Class C Telegraphy

Beam tube connection. Key-down conditions per tube without modulation

DC Plate Voltage	400	500	600	750 volts
DC Grid-No. 2 Voltage§	250	250	250	250 volts
Series resistor	20000	42000	50000	85000 ohms
DC Grid-No. 1 Voltage **‡	—45	—45	—45	—45 volts
Grid current bias resistor	12800	12800	12800	12800 ohms
Cathode bias resistor	410	410	410	410 ohms
Peak RF Grid-No. 1 Voltage	65	65	65	65 volts
DC Plate Current	100	100	100	100 ma.
DC Grid-No. 2 Current	7.5	6	7	6 ma.
DC Grid-No. 1 Current (Approx.)	3.5	3.5	3.5	3.5 ma.
Driving Power (Approx.)	0.2	0.2	0.2	0.2 watt
Power Output (Approx.)	25	30	40	50 watts

FREQUENCY DOUBLER

Beam tube connection. Key-down conditions per tube without modulation.

DC Plate Voltage	750 volts
DC Grid-No. 2 Voltage§ (Series resistor 91000 ohms)	250 volts
DC Grid-No. 1 Voltage **‡	—90 volts
Grid Current bias resistor	18000 ohms
Cathode bias resistor	900 ohms
Peak RF Grid-No. 1 Voltage	110 volts
DC Plate Current	90 ma.
DC Grid-No. 2 Current	5.5 ma.
DC Grid-No. 1 Current (approx.)	5 ma.
Driving Power (approx.)	0.45 watt
Power Output (approx.)	40 watts

***Obtained from modulated fixed supply, or from modulated plate supply through resistor of value shown, or from unmodulated supply through audio choke.

**The total effective grid-No. 1 circuit resistance should not exceed 25000 ohms.

§Obtained from separate source, from a bleeder network, or from plate supply through a series resistor of value shown.

†Bias can be obtained from a fixed supply, or from a cathode resistor of value shown, or grid resistor of value shown, or from any combination that provides specified bias voltage.

‡For linear 100% modulation the total bias should be obtained from a grid resistor of the value shown, bypassed for rf only.

807 DRIVES 8005 FINAL IN FLEXIBLE FOUR STAGE RIG

READY FOR A RAG-CHEW

This fine looking rig has an electronic keying system, quick band change, plug in coils, and meter switching—important in a unit designed for convenient operation and quality service.

AN ANALYSIS OF GRID DRIVING POWER AS LISTED IN TUBE OPERATING DATA

One important question that's sure to come up in the design of a new transmitter is how much power is needed to adequately drive the individual stages. Tube manufacturers have set up driving power figures in typical operating data, but unless this information is interpreted correctly, the driver stages may be under-designed.

The value of driving power shown in tube data bulletins includes only the actual power input to the grid plus the power lost in the bias supply. *It does NOT include rf losses that occur in the tube, tank circuit, socket and wiring, or losses in the tubes, caused by transit-time loading.*

It is not feasible for the tube manufacturers to give total driving power figures, because there is no way of anticipating conditions under which the tubes will be used. Grid power requirements will vary considerably, even in well-engineered designs, and the extreme ranges are quite large. It is better, therefore, that printed specifications indicate only the sum of grid power and bias losses.

Because the driver tube must supply all the losses between its plate and the grid of the driven tube, these losses must be added to the figure given in the tube data for driving power requirements. On an average, in the frequency range up to 30 Mc, the losses are large enough to dictate the choice of a driver tube which has a rated output of about twice the grid power rating of the driven tube.

Driving-power measurements are usually made at 100 kc—where rf losses in the tube are negligible—by measuring the peak rf grid voltage (Eg) and the average grid current (Iav). Then, the relation $Wd = 0.9\ Eg\ Iav$, gives the driving power in watts. This is the figure shown in tube bulletins.

At higher frequencies consideration must be given to rf and transit-time loading losses. If the stage in question is to operate above 30 Mc, it is advisable to provide 3 to 10 times the published low-frequency driving power figure in order to insure sufficient drive plus a reasonable margin for safety.

After the design has been crystallized and the transmitter constructed, tests and adjustments should be made to insure that the

UNIT COVERS 80 TO 10 METER BANDS FOR PHONE AND CW WITH MEDIUM POWER

By GEORGE D. HANCHETT, JR., W2YM

The desire for a compact and flexible transmitter that would cover all the bands from 80 meters to 10 meters with an input of 300 watts for cw and 250 watts for phone prompted the design of the rig to be described. Many hours of thought resulted in plans for a unit using 80-meter crystals and having a minimum of four stages with an 8005 final driven by an 807. A fully electronic keying system, quick band-change, plug-in coils, meter switching for convenience and low cost, and symmetry of panel controls completed the goals we set up for our transmitter. Then we rolled up our sleeves and went to work.

The transmitter was built completely on a 17" x 13" x 3" cadmium plated chassis. Its panel size is 19" x 10½". The power supply, not illustrated, was built on another chassis of the same size.

The oscillator and multiplier plate-tuning condensers, as well as the meter switch, are mounted under the chassis with their control knobs brought out to the front panel. In order to keep the oscillator tank leads as short as possible, the oscillator tuning condenser is mounted slightly to one side; drive is accomplished through a flexible shaft.

Both oscillator and multiplier tank condensers are mounted on polystyrene strips which are, in turn, affixed to metal supporting brackets. By means of this insulating method together with bakelite shafts, it is possible to isolate the condensers from ground, thereby allowing the dc voltage to be applied to the rotors. The arrangement eliminates the need for costly mica blocking capacitors capable of carrying tank currents.

Quick Band Changing

The band-change switch is a four-pole, three-position wafer type. The first pole of the switch in both the 20-meter and the 10-meter position applies plate voltage to the 6L6 multiplier. The second pole is used

BEHIND THE SCENES
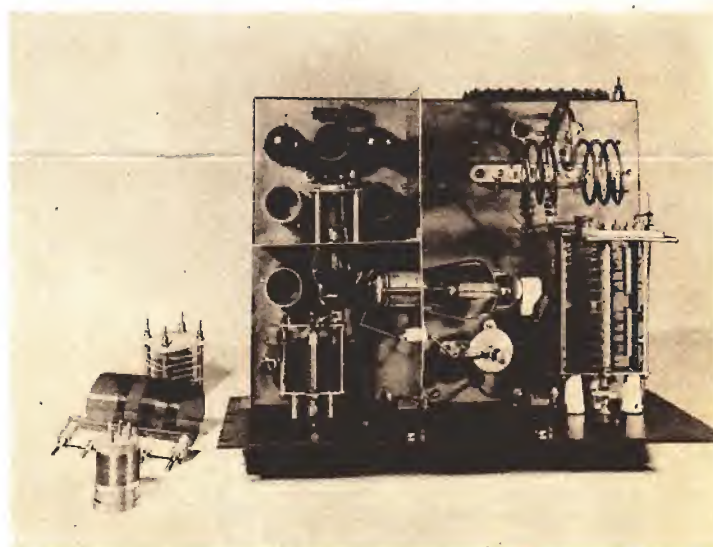
A top view of the transmitter discloses a symmetrical layout to achieve maximum operating efficiency as well as an attractive appearance.
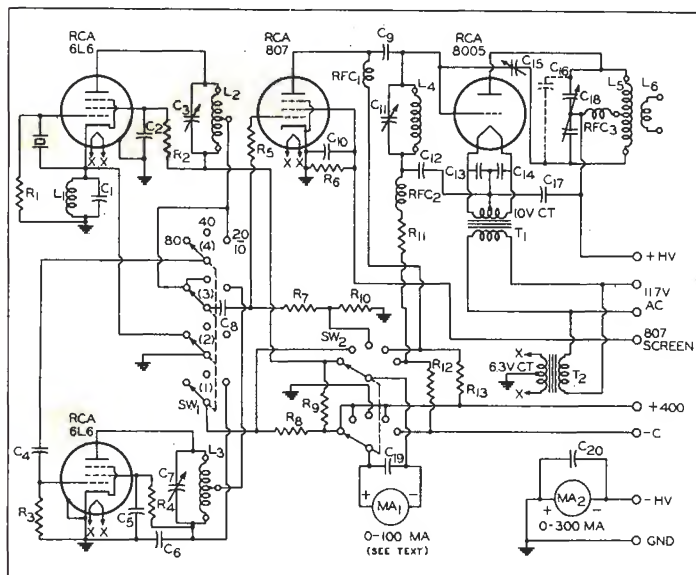
Figure 1. Transmitter schematic.

FOUR STAGE RIG

(Continued from Page 1, Column 4)

to short the cathode coil of the oscillator only when its plate circuit is tuned to the fundamental wave length of 80 meters. The third pole connects the grid of the 807 to the proper driving circuit. The fourth and last pole removes the excitation to the 6L6 multiplier when it is not in use.

One novel feature of this transmitter is that both the 807 buffer and the 8005 final are mounted horizontally. Better placement of parts can be accomplished when the tubes are placed in this position. The photographs show that the grid connection comes close to the grid tank and that the plate is near the plate tank. Those short connections are extremely helpful for 28-Mc operation.

When a filamentary tube such as the 8005 is mounted horizontally, care should be taken to see that the plane of the filament is vertical. Tubes other than the 8005 may be used in this manner except those

Figure 2. Schematic used in adjusting meter shunts.

employing helical filaments which are not recommended for horizontal mounting.

Note that the 8005 has its socket mounted on the vertical shield partition. Shielding of the 807 is achieved with two aluminum shields. One shield runs perpendicular to the panel and a little to the left of center. The other is mounted parallel to the panel and slightly back of the chassis center. This arrangement adequately shields the 807 plate from its input

circuit and also shields the 807 from the final tank circuit.

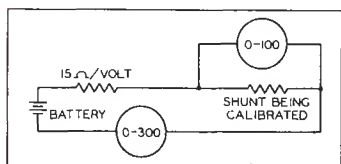To eliminate the possibility of parasitic oscillations in the 807 buffer stage, connect a 50-ohm non-inductive resistor in the grid circuit. This resistor should be placed as close as possible to the grid socket terminal.

On 3.5 to 4.0 megacycles, in order to obtain a desirable tank Q of 12, essential for reduction of unwanted harmonic output, it is necessary to add extra capacitance to the split-stator condenser. This is provided by the plug-in condenser, C 16. Two turns are removed from each end of the coil (L5) in order to obtain resonance with the larger total capacitance.

Metering Procedure

Metering of the 8005 plate circuit takes place in the negative return of the high-voltage supply. This method permits the meter to be mounted on the panel and not be a shock hazard. Metering the low-power stages as well as the grid of the 8005 is accomplished with a meter switch and a 100-ma instrument. The installation of new shunts permanently wired in for each position permits the meter to be switched to any of several circuits. This provides a very simple arrangement, *but one precaution must be taken. The meter switch must be of the non-shorting type.* Use switches such as Centralab #1405 or Mallory #1315L. For this transmitter the internal shunt was removed from the meter and five new shunts of equal resistance were constructed. Each was made from about 4 feet of #28 enameled wire, wound on a solder-lug terminal strip.

To adjust the new shunts, use a battery, a fixed resistor having about 15 ohms per battery volt, and the 300-ma meter (8005 plate), all in series with the 100-ma meter and shunt to be adjusted. This hookup is shown in Fig. 2. Wire should be

removed from the home-built shunt until both meters read the same.

The meter positions of the switch are as follows:

  1—oscillator plate current
  2—multiplier plate current
  3—807 grid current
  4—807 plate current
  5—8005 grid current

The two power supplies required for the transmitter are both mounted on a single 3" x 13" x 17" chassis. One is a low-voltage supply for the oscillator, multiplier, and buffer, and the second is a high-voltage supply for the 8005. Fig. 3 is a schematic diagram of the supplies. Bias voltage is obtained from a half-wave rectifier connected to the bias tap on the 400-volt power transformer. With no excitation to the 8005 final amplifier the grid bias should not be less than 70 nor more than 90 volts.

Electronic Keying

Keying of the transmitter is done electronically in the screen-grid circuit of the 807. This method was originated by W2RYI, and gives excellent clickless keying. In the key-up condition, the grid of the control tube, a 6L6 in this case, operates at zero bias resulting in a low internal tube resistance. This low resistance reduces the voltage at the anode of the voltage regulator tube (OC3/VR105) below that required for ionization. With no ionization, the VR tube is non-conductive and the result is an open circuit to the screen grid of the 807. Note in the circuit diagram that a 0.15-megohm resistor is connected between screen grid and ground to bleed off any charges collecting on the screen grid and to hold it at ground potential in the key-up position.

When the key is in the key-down position, cutoff voltage is applied to the control grid of the 6L6. This produces a very high internal resistance in the 6L6 so that adequate ionizing voltage appears at the

anode of the VR tube. Now, the VR tube will ionize or fire, and complete the circuit between the screen grid and its supply voltage.

Capacitor C5 of the power supply is used to prevent key clicks. Increasing the size of the capacitor will increase the lag; reducing it decreases the lag. The novel features of this system are that only very small currents need be keyed and that the keying lag may be adjusted by changing the size of the capacitor.

Tuning Up the Rig

Tuning up the transmitter is quite simple. After the proper crystal and coils for the band desired are selected, the oscillator tuning condenser should be rotated to obtain the usual dip. The plate current of the oscillator will run about 20 to 25 ma on 80 meters and 25 to 30 ma on all other bands.

When the multiplier is to be used, tune it to resonance as quickly as possible because abnormally large currents flow when its plate circuit is out of adjustment. Normally, the plate current of the 6L6 will run about 30 ma on all bands.

Next, switch the meter to the 807 grid position and retune the multiplier or oscillator plate tuning condenser for maximum grid current. The 807 grid current should be between 4 and 5 ma on all bands. Switch the meter to the 807 plate circuit and hold the key down, then tune the 807 plate circuit for minimum current. The value should be in the neighborhood of 60 to 70 ma for all bands except 10 meters. On 10 meters the 807 plate current will run about 85 ma because in this position the 807 is operating as a doubler. When tuning the low power stages do not apply high voltage to the 8005.

When the driver stages have been tuned, the grid circuit of the 8005 should then be tuned. No high voltage should as yet be applied to the 8005. The meter switch is turned to the 8005 grid position and the
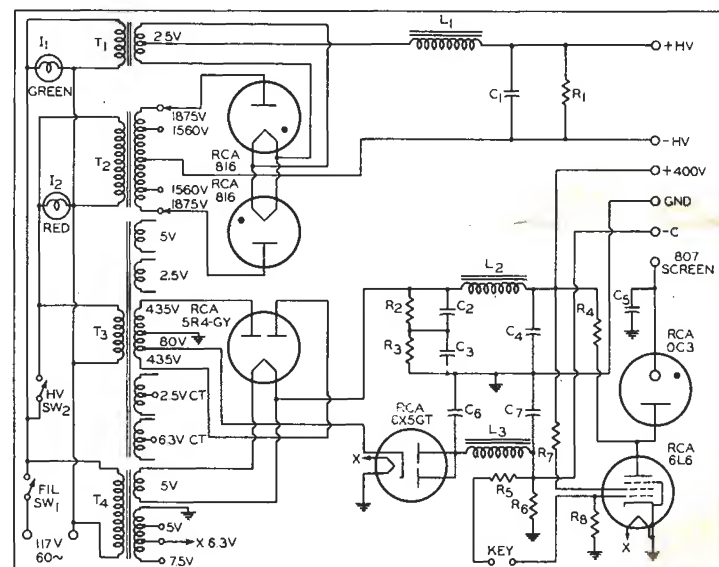

Figure 3. Schematics of power supplies.

Coil Data				
Wavelength Band meters	L_2	L_3	L_4	
80	A		B	
40	C		D	
20	C	E	F	
10	C	E	G	

80 meters Coil A — 30 turns # 22 wire, winding length 1⅜", tap at 12 turns.
Coil B — 27 turns # 20 wire, winding length 1¼", no tap.

40 meters Coil C—17½ turns # 20 wire, winding length 1¼", tap at 8 turns.
Coil D — 15 turns # 18 wire, winding length 1¼", no tap.

20 meters Coil E — 10 turns # 18 wire, winding length 1", tap at 5 turns.
Coil F — 6 turns # 18 wire, winding length 1", no tap.

10 meters Coil G — 3 turns # 14 wire, winding length 1¼", no tap.

All coils wound on National XR-5 forms or equivalent, 1½" diameter, 2¼" long.

807 plate tank adjusted to obtain maximum 8005 grid current. This grid current should run 30 to 35 ma on all bands but will be lower on the higher frequency bands. It is worth mentioning that the 807 does a good job of driving the 8005, even though it has a plate supply of only 400 volts and is capacitively coupled to the 8005 grid.

After the final amplifier has been neutralized as described below, the high voltage may be applied and the plate circuit tuned to resonance. Then, the pick-up loop can be connected to the antenna transmission line and the antenna coupling adjusted to load the tube to the desired plate current which, however, must not exceed 200 ma.

Neutralizing the 8005

Neutralization of the 8005 can be done as follows: with the high voltage off, tune the plate tank of the 8005 through resonance and observe the needle kick on the meter caused by a shift in grid current. Change the setting of the neutralizing condenser and check grid-current kick again. If the kick becomes less than before, the adjustment of the neutralizing condenser was in the correct direction. This procedure should be repeated until there is absolutely no kick noticeable on the grid meter. When the final has been neutralized, it will not require readjustment with change in operating frequency.

The 1875 volt power transformer T2 is tapped at 1560 volts. The full secondary will provide 1500 volts for the 8005 when it is used on CW. The 1560-volt ac tap will provide 1250 volts for the tube when it is plate modulated.

The builder of this transmitter should not experience any trouble in obtaining top performance. It is one of the most easily constructed and conveniently operated rigs that the author has used in his 18 years of Ham radio.

PARTS LIST—TRANSMITTER

C1	200 μμf, mica, 500 volts working
C2, C5, C6, C10	0.002 μμf, mica, 500 volts working
C3, C4	100 μμf, variable, 500 volts working
C7	50 μμf, variable
C8	500 μμf, mica, 500 volts working
C9	500 μμf, mica, 600 volts working
C11	65 μμf, mica, 0.070 spacing
C12	0.002 μμf, mica, 600 volts working
C13, C14	0.005 μμf, mica, 500 volts working
C15	National, NC 800 neut. condenser
C16	25 μμf, padding condenser, 0.25" spacing
C17	0.003 μμf, mica, 2500 volts working
C18	50 μμf per section, 0.171" spacing
C19, C20	0.002 μf, mica
R1	250,000 ohms, ½ watt
R2, R4	20,000 ohms, 1 watt
R3	100,000 ohms, 1 watt
R5	50 ohms (carbon) ½ watt
R6	150,000 ohms, 1 watt
R7	25,000 ohms, 1 watt
R8, R9, R10, R12, R13	Special meter shunt (#28 enameled wire on tie strip) see text
R11	3,000 ohms, 10 watts
RFC1, RFC2	National R-100
RFC3	National R-300
L1	10 turns of #20 wire wound 1" length on National form XR-5
L2, L3, L4	See coil data
L5, L6	B & W TVL coils
SW1	4 pole, 3-position Isolantite switch, non-shorting type
SW2	2 pole, 5-position switch
T1	10 volt, filament transformer
T2	6.3 volt, filament transformer

PARTS LIST — POWER SUPPLY

C1	4 μf, at 2000 volt, oil impregnated paper
C2, C3	8 μf, 450 volt, electrolytic
C4	20 μf, 450 volt, electrolytic
C5	0.05 to 0.25—adjust to suit keying requirements
C6, C7	20 μf, 150 volt, electrolytic
R1	50,000 ohms, 100 watts
R2, R3	0.5 megohm, 1 watt
R4	5,000 ohms, 25 watts
R5	10,000 ohms, ½ watt
R6	3,000 ohms, 10 watts
R7	50,000 ohms, 10 watts
R8	100,000 ohms, ½ watt
L1	12 h at 300 ma.
L2	13 h at 250 ma.
L3	8 h at 55 ma.
SW1, SW2	SPST toggle, 12 amp rating,
I1, I2	115 volt, 6-watt indicator panel lamp
T1	Thordarson T19F75 or equivalent, 2.5 volt at 5 amps.
T2	Thordarson T19P60 or equivalent, 1875-0-1875 and 1560-0-1560 at 300 ma.
T3	Thordarson T75R50 or equivalent, 435-0-435 at 250 ma., 80 volt bias tap
T4	Thordarson T19F76 or equivalent, 5 volt at 3 amps, 6.3 volt at 6 amps.

AN UNDER CHASSIS VIEW

Logical arrangement of components and wiring adds to the transmitter's operating stability.

NEW 816 VOLTAGE RATINGS

7500 volts is the new peak inverse voltage rating for the RCA-816. A pair of these tubes can now be used in a full-wave rectifier with a standard plate transformer having a 5000-volt center-tapped secondary. Such use is well within the new rating and with average quality components in a choke-input circuit will provide 250 ma. and a filter output voltage of about 2150 volts.

ECHOS

The "Torpedo Twin" article which appeared in the May-June issue of HAM TIPS listed R10 and R11 as 2-6000 ohm resistors in series. Actually the total resistance should have been 42,500 ohms minimum. A value of 45,000 ohms, or more, will be required in practice, and this can be obtained from a 20,000-ohm resistor in series with a 25,000-ohm resistor.

GRID DRIVING POWER

stages are being properly driven. If, as in many cases, an amplifier tube is to be operated with conditions differing somewhat from those published under a set of suggested typical operating conditions, the performance can be checked as follows. First, load the amplifier to the desired value of plate current. Then vary the grid current slowly (tank circuit tuning remaining unchanged) and note the change in output.

If the change in output is roughly proportional to the change in grid drive, the stage is underdriven. Then drive should be increased until very little increase in output results from a large increase in drive. Under this condition, the stage is said to be saturated. Of course, the maximum rated value of dc grid current should not be exceeded.

The penalties for an underdriven stage are low power output, low efficiency, and if the stage is plate modulated, severe distortion at high levels of modulation. The latter condition will readily be recognized as downward modulation, and if a pure sine wave is used for test, a decrease in average plate current will be noted as the modulation level is increased.

Correct Grid Drive Important

It is very desirable to saturate amplifiers, especially those driven by a series of frequency multipliers. This comes about because it is rarely possible to saturate frequency multipliers and stay within tube ratings. Consequently, a small decrease in supply voltage on the multiplier stages may cause a large decrease in grid drive and in output of the final amplifier stage. It is important, therefore, that the amplifier grid be saturated so that full output is maintained regardless of variations in supply voltages.

It is possible to overdrive as well as underdrive tubes. However, overdrive occurs rarely. There is little to be gained by over-driving and something to lose. Although there should be no actual damage to the grid or cathode unless the maximum ratings for dc grid current or dc grid bias are exceeded, over-driving can cause excess harmonic radiation and low power gain.

Over-driving a beam tube or pentode may cause the screen grid to be overloaded before the control grid. This condition may be checked by metering the screen current to determine whether the screen input is within ratings. Adjustment of both bias and screen voltage may be necessary to allow the tube to be properly saturated and still remain within screen input ratings.

The correct amount of grid drive is an important detail of power tube application. With other conditions properly maintained, it insures high power gain, high plate efficiency, and long tube life.

RCA-8005 TRANSMITTING TRIODE

FULL INPUT TO 60 MEGACYCLES.

Amateur Net **$7.00**

Features

- Ceramic washer minimizes corona discharge—provides superior bond to glass and plate cap, eliminating strain.
- Nonex hard-glass envelope will not crack, buckle or puncture under high operating temperatures.
- Oversized 32.5 watt filament—the same as used in much larger tubes—has enormous reserve of emission.
- Drawn-tungsten seal rods have smoother surfaces—hence, provide superior seals against air leakage.
- Zirconium-coated molybdenum anode provides unusually rapid heat dissipation and permits greater power input.
- Sturdy metal base and low-loss ceramic insert combine strength with high heat and insulation resistance.
- A pair of 807's in Class B will plate modulate an 8005. A pair of 811's in Class B will handle two 8005's.
- The 8005 can be used within its ratings to replace any of the older types such as the 203A, 211, and 845. It is only necessary to install a new socket, install a flexible lead to the plate cap, and re-neutralize the circuit.

Application Considerations

- *Power Gain.* Figure on a grid-to-plate power gain of 20 to 1 and you will have ample drive available. One 807 driver is okay. At 30 Mc, an 807 or 6L6 doubler with only 400 volts on its plate will do the job. An 807 buffer or doubler will drive a pair of 8005's.
- *Neutralization.* Adjust neutralizing condenser so that the grid-current peak and the plate-current dip occur at exactly the same point of plate tank tuning.
- *Circuit Q.* In single-ended service, the split-stator plate-tuning capacitance should be approximately 0.8 $\mu\mu f$ per section, per meter.
- *Mounting.* The 8005 can be mounted horizontally as well as vertically.

8005 TRANSMITTING TRIODE
GENERAL DATA

Electrical:

Filament, Thoriated Tungsten:
Voltage ....10 ac or dc volts
Current ....3.25 amp
Amplification Factor 20
Direct Interelectrode Capacitances:
Grid to Plate .... 5　$\mu\mu f$
Grid to Filament .... 6.4　$\mu\mu f$
Plate to Filament .... 1.0　$\mu\mu f$

Mechanical:

Mounting Position.............................Vertical, base down; or Horizontal,
pins 1 and 4 in vertical plane
Overall Length ....6-13/32" ± 5/32"
Seated Length ....5-25/32" ± 5/32"
Maximum Diameter ....2-7/16"
Bulb ST-19
Cap ....Medium, with insulating Collar
Base.............................Medium Metal-Shell Small 4-Pin, Bayonet

AF POWER AMPLIFIER AND MODULATOR—CLASS B
Maximum Ratings,
Absolute Values:

	CCS†	ICAS‡	
DC Plate Voltage	1250 max.	1500 max.	volts
Max.-Signal DC Plate Cur.*	200 max.	200 max.	ma.
Max.-Signal Plate Input*	225 max.	250 max.	watts
Plate Dissipation*	75 max.	85 max.	watts

Typical Operation:
Values are for 2 tubes

DC Plate Voltage	1250 . .	1500 . .	volts
DC Grid Voltage#	−55 . .	−67.5 . .	volts
Peak AF Grid-to-Grid Voltage..................	290 . .	330 . .	volts

> HAM TIPS is published by the RCA Tube Department, Harrison, N. J., and is made available to Amateurs and Radio Experimenters through RCA tube and parts distributors.
>
> H. S. STAMM..*Editor*
> J. H. OWENS.............................*Technical Editor*

	CCS†	ICAS‡	
Zero-Signal DC Plate Current....................	40 . .	40 . .	ma.
Max.-Signal DC Plate Current	320 . .	330 . .	ma.
Effective Load Resistance (plate-to-plate) ...	8000 . .	9800 . .	ohms
Max.-Signal Driving Power (Approx.)..........	4 . .	5.5 . .	watts
Max.-Signal Power Output (Approx.)	250 . .	330 . .	watts

PLATE-MODULATED RF POWER AMPLIFIER—CLASS C TELEPHONY
Carrier conditions per tube for use with a max. modulation factor of 1.0
Maximum Ratings,
Absolute Values:

	CCS†	ICAS‡	
DC Plate Voltage	1000 max.	1250 max.	volts
DC Grid Voltage	−200 max.	−200 max.	volts
DC Plate Current	160 max.	200 max.	ma.
DC Grid Current	45 max.	45 max.	ma.
Plate Input	160 max.	240 max.	watts
Plate Dissipation	50 max.	75 max.	watts

Typical Operation:

	CCS†	ICAS‡	
DC Plate Voltage	1000 . .	1250 . .	volts
DC Grid Voltage§	−195 . .	−195 . .	volts
	7000 . .	7000 . .	ohms
Peak RF Grid Voltage	350 . .	350 . .	volts
DC Plate Current	160 . .	190 . .	ma.
DC Grid Current (Approx.)¶	28 . .	28 . .	ma.
Driving Power (Approx.)¶	9 . .	9 . .	watts
Power Output (Approx.)	115 . .	170 . .	watts

RF POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY
Key-down conditions per tube without modulation ●
Maximum Ratings,
Absolute Values:

	CCS†	ICAS‡	
DC Plate Voltage	1250 max.	1500 max.	volts
DC Grid Voltage	−200 max.	−200 max.	volts
DC Plate Current	200 max.	200 max.	ma.
DC Grid Current	45 max.	45 max.	ma.
Plate Input	240 max.	300 max.	watts
Plate Dissipation	75 max.	85 max.	watts

Typical Operation:

	CCS†	ICAS‡	
DC Plate Voltage	1250 . .	1500 . .	volts
DC Grid Voltage**	−115 . .	−130 . .	volts
	3800 . .	4000 . .	ohms
	520 . .	560 . .	ohms
Peak RF Grid Voltage	240 . .	255 . .	volts
DC Plate Current	190 . .	200 . .	ma.
DC Grid Current (Approx.)¶	30 . .	32 . .	ma.
Driving Power (Approx.)¶	6.5 . .	7.5 . .	watts
Power Output (Approx.)	170 . .	220 . .	watts

† Continuous Commercial Service.
‡ Intermittent Commercial and Amateur Service.
*Averaged over any audio-frequency cycle of sine-wave form.
For ac filament supply.
§ Obtained preferably from grid resistor of value shown, or combination of grid resistor with either fixed supply or suitably by-passed cathode resistor.
¶ Subject to wide variations depending on the impedance of the load circuit.
● Modulation essentially negative may be used, if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.
** Obtained from a fixed supply, by grid resistor (3800, 4000) or by cathode resistor (520, 560).

MODERN SPEECH AMPLIFIER USES 6AS7-G OUTPUT TUBE

KING OF THE KILOWATTS

Amateurs are advised that it is now practical to operate the RCA-833-A at a full kilowatt input in plate-modulated class C telephony service, without the use of forced-air cooling. Typical data for this new natural-air-cooled operation are yours for the asking. Write to Commercial Engineering, RCA, Harrison, N. J.

More Versatile Than Ever!

Amateur Net Just $45.00

EASILY BUILT ELECTRONIC BIAS SUPPLY GIVES REMARKABLE VOLTAGE REGULATION

By GEORGE D. HANCHETT, JR., W2YM

Zero-bias tubes don't need it, but many of the popular modulator tubes used by Amateurs do require some negative grid bias. The stringent requirement for good voltage regulation makes the problem quite difficult because it rules out the simple type of bleeder-filter circuit. As a result "B" batteries have been used extensively for class "B" modulator bias. However, a review of the literature revealed a better solution to the problem in a paper by George E. Pihl.*

The electronic bias supply described has better voltage regulation than dry batteries. It has greater flexibility, longer life, and is consequently less expensive. Of equal importance, it is a device which can be assembled easily in a few hours by the average Amateur.

Basically, it consists of a small power supply which delivers about 20 ma of current to an output triode. The voltage drop across the triode is used as the regulated bias voltage. Associated with the triode is a pentode dc amplifier and two glow-discharge "VR" tubes which serve to vary the grid voltage of the output triode so that a con-

stant voltage is maintained across it. The voltage regulator tubes take about 20 ma as a "keep-alive current," so the rectifier and filter must supply a total current of about 40 ma.

The theory of operation can be explained by reference to the diagram in Fig. 2. Since the voltage drop across V_4 and V_5 is in parallel with the voltage drop across V_2 and R_5, any change in voltage across V_4 will appear in its entirety across R_5, because the voltage drops across both VR tubes remain fixed.

R_4 is the cathode bias resistor of V_3; therefore, any voltage change across it appears as a grid voltage change on V_3. This change in grid voltage is amplified by V_3 and appears across R_4 which is connected

(Continued on Page 3, Column 4)

*"A Voltage Stabilized Bias Supply for Power Tubes" by Geo. E. Pihl, Northeastern University Publication Bulletin #10—April 1943.

UNIQUE FEATURES OF TWIN TRIODE LEAD TO ITS CHOICE AS AUDIO TUBE

By J. H. OWENS, W2FTW

Something old is something new in speech amplifiers. This latest design reverts to an old-fashioned triode output stage, and dispenses with modern inverse-feedback circuits. Such is the trend of progress!

But regardless of the old fashioned approach in design, *the output tube in this amplifier is really ultra-modern.* It's the 6AS7-G, a high-power twin-triode that was designed for use in regulated power supplies and television receivers. As an audio tube, it has two features which make it excellent for speech amplifier use:

Extra-low ac plate resistance. Only 560 ohms, plate-to-plate, in a push-pull circuit.

Extra-high plate efficiency. Actually equal in efficiency to multi-grid tubes.

And what is wrong with multi-grid power tubes? Aren't they hum-free even with a mediocre filtered plate supply? Can't they be driven to full output with a very small grid signal? Aren't they exceptionally low in cost?

Yes. In fact, if they are fed into a constant resistance load, there is nothing particularly or peculiarly wrong with them. *Unfortunately for radio Amateurs, however, class B modulator grids do not present* a constant impedance. Instead, they are characterized by a constantly varying impedance, and one which varies sharply right during the cycle of an audio frequency signal.

To fully appreciate the importance of this unfavorable situation, consider its relation to one pertinent characteristic of multi-grid power tubes. If the load is removed from a pentode or beam tube power amplifier, the output voltage will rise about five or more times its fully loaded level. Imagine then, the distortion that is generated when one of the modulator grids traverses the threshold from positive to negative voltage.

(Continued on Page 2, Column 1)

STABILITY PLUS STYLE

This functional looking speech amplifier delivers 12 watts of actual power output to a load at less than 4% distortion.
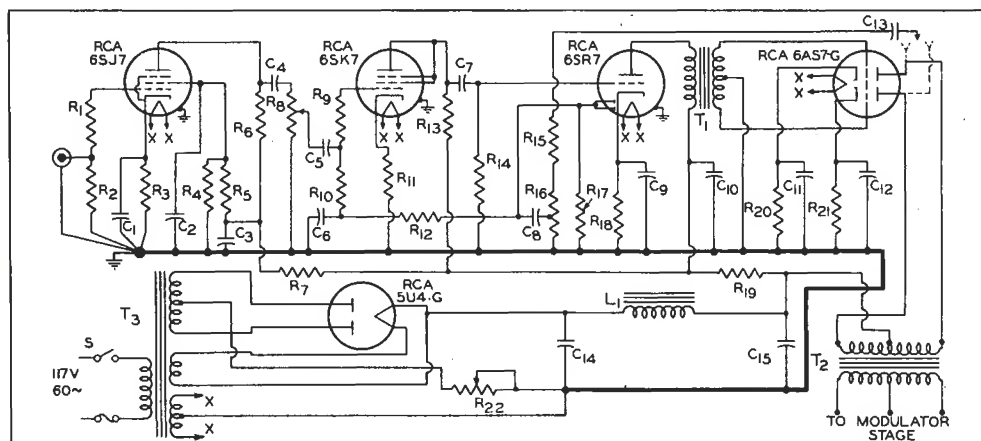
Fig. 1. Schematic of speech amplifier.

SPEECH AMPLIFIER

(Continued from Page 1, Column 4)

In terms of design practice, a speech amplifier must have good voltage regulation of the output signal. This can be achieved by use of tubes, such as the two sections of the 6AS7-G, having very low ac plate resistance. If multigrid tubes, with a plate resistance of about 100,000 ohms are used, it is necessary to use a great amount of feedback to obtain good regulation. This method is equally satisfactory, providing the feedback loop can be kept degenerative all the way from one cycle to a couple of hundred thousand cycles per second.

If the degenerative condition is not maintained, the amplifier is likely to motor-boat in the familiar "putt-putt" fashion, or voice its displeasure in a strident wail, or it may really cause confusion with random bursts of ultrasonic parasitic oscillations. Radio design engineers, working in manufacturers' laboratories, with the benefit of elaborate test equipment, are able to achieve such a control, but the average Ham shack is not so well equipped.

Pentode Difficulties

The use of a 6AS7-G eliminates pentode feedback difficulties, and at the same time gets around certain objections to filament-type triodes such as the 2A3, 6A3, and 6B4G. These tubes generate filament hum that can't be removed easily without the use of negative feedback. They also produce some distortion in a class AB circuit unless matched tubes are used or a bias correcting network is provided. Furthermore, they do not have the high plate efficiency of beam tubes or the 6AS7-G.

The 6AS7-G eliminates these objections. Filament hum is entirely removed by its heater-cathode construction. There are two triode units in a 6AS7-G and each one has its own cathode which comes out to a separate base pin. It becomes possible, therefore, to use separate cathode bias resistors and by-pass capacitors for each triode, permitting the two sections to be self-matching. Self-bias balancing of 2A3's would require two filament transformers, one for each tube.

Another important consideration is plate efficiency. For class A, or class AB_1 service, efficiency is simply related to the position or angle of the zero-bias line on the plate family of curves. Reduced to simple terms, high efficiency is obtained if a tube is able to draw high plate current at low plate voltage when the grid swings to zero. The efficiency is, in effect, a measure of the plate voltage swing that can be obtained with a given plate supply voltage and peak signal plate current.

Circuit Considerations

Reference to the plate family will show that a 6AS7-G plate will swing down to 30 volts when the plate current is 100 ma and the grid is at zero. This is identical to the performance of a 6L6 under equal conditions with a screen grid voltage of 250. By contrast, a 2A3 plate will swing down only to about 90 volts. When the 2A3 is operated with a plate-supply voltage of 300 volts, a half-cycle voltage of about 210 volts can be developed in the plate circuit with a 100 ma swing of plate current. A 6AS7-G will develop 220 volts with the same swing of plate current, but with a plate supply of only 250 volts.

An examination of the circuit design of the amplifier is appropriate at this point. As illustrated in Fig. 1, the schematic is quite conventional. A 6SJ7 was chosen for the input stage because of its high gain, *as well as its comparative stability in an rf field.*

The second stage tube is a 6SK7, triode connected. This type was chosen because it provides a variable-gain electrode for the injection of a dc compression or AMC voltage.

The third stage is a 6SR7, chosen because it has two diodes. If it were not for the AMC requirement, the type 6J5 would have been used in both the 6SK7 and 6SR7 stages. Plate, grid, and cathode resistors and capacitors would remain the same, but all components in the compression circuit would be omitted, and the 6SK7 series grid resistor would be connected to the movable arm of the volume control.

The 6SR7 is, of necessity, transformer-coupled to the 6AS7-G. Resistance-coupling will not supply the large grid swing that the 6AS7-G grids require. A transformer might be a disadvantage in an amplifier used for musical reproduction, but it has merit in a speech amplifier since it can be used to control the frequency response characteristic. With all-resistance-coupling, the amplifier response is flat, but the transformer changes the curve and gives it a rising high-frequency characteristic.

If a high-fidelity transformer were used, with parallel choke feed, the response would remain flat, or it could be tilted up at the low end. But when the transformer primary carries the 6SR7 dc plate current, its inductance is reduced. This decreases the impedance at the low-frequency end, reduces the response at that end, and, in effect, tilts up the high end.

Voice Phenomena

If a very small and cheap transformer is used, the effect is emphasized. With a two-pound transformer of intermediate quality, there is just enough high-frequency pre-emphasis to make speech crisp and highly intelligible.

High-frequency pre-emphasis plus bandwidth restriction has been prac-

tised by communication companies for many years. Suppression of fundamental voice frequencies below 400 cycles does not affect the intelligibility or the pitch of speech, but it does remove the sounds which would otherwise absorb 50% or more of the power-handling capabilities of the transmission medium.

To dwell a moment on voice phenomena, it is known that the deeper vowel formants range from approximately 400 to 900 cycles per second. The upper vowel formants go from 900 to about 2400 cps. Then the dominant sibilants occupy the band up to about four or five thousand cps. Within this range of 400 to 5000 cps. are the important sounds that help create and identify spoken words.

Other Considerations

The development of a story about the new 6AS7-G in a speech amplifier affords the opportunity to review other important design practices. Such things as rf feedback, suppression and hum reduction are too important to be overlooked.

To eliminate rf rectification and feedback, it is only necessary to prevent rf voltages from appearing between the grids and cathodes of the low-level tubes. Shielding is therefore very important, and metal tubes simplify the job. The metal shells are grounded to the chassis with leads as short as practicable.

Series grid resistors are more effective than chokes in keeping rf off of the grid terminals. Quarter-or half-watt carbon units should be used, and the ends going to the socket grid terminals should be clipped short. No other wiring should touch these grid socket terminals. The resistance values given in the parts list for these series grid resistors should be satisfactory for all circumstances, but they may be increased to 100,000 ohms each without ill effects.

Because the point most sensitive to rf feedback is the 6SJ7 grid, it should be examined first if feedback occurs. Incidentally, these grid resistors reduce the response to very high audio frequencies, thereby helping to narrow the channel and keep down the level of modulation splatter.
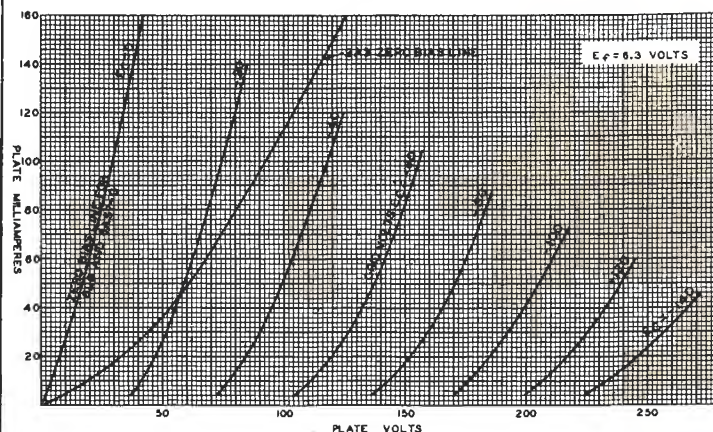
Average plate characteristics of the 6AS7-G for each triode unit.

Hum and Noise

The grounding system is the most important design factor to observe precisely in the construction of a high-gain amplifier. In fact, there are two grounds, a mechanical ground and an electrical ground. The mechanical ground is the chassis, metal component shields, inductor cores, and the metal tube shells. The electrical ground is the high-voltage dc return path to the center tap of the power transformer. The two grounds are separate, and are joined at only one single point near the input tube.

The electrical ground bus goes from the filter, to the power stage, to the 6SR7, to the 6SK7, to the 6SJ7, and finally to the point of contact with the mechanical ground. All electrical returns are made to it in progression as shown. This is important because it prevents the low-level stages "seeing" minute voltage drops produced by the flow of currents from higher-level stages.

The 6SJ7 returns are the most critical. In order to get high gain with lowest hum, it is necessary to bring the ac and dc grid and cathode returns to a common point. The microphone cable shield also grounds at this point rather than at the chassis where the microphone jack is located. The jack must be insulated from the chassis. From this final terminal point in the electrical ground system, a short wire goes to a convenient point on the chassis ground near the 6SJ7 socket.

The 6SJ7 is also the most critical tube for microphonics. To keep such noises at a minimum, the tube is cushion mounted on rubber grommets. On the same cushioned socket mounting plate are solder-lug terminal strips on which all of the associated resistors and capacitors are mounted. Connections from these to other parts of the circuit are made through flexible "test lead" wires.

The Filter

One disadvantage of low-mu output triodes is that they require a well filtered plate supply. The filter choke must be employed as shown because a large portion of any power supply ripple will be transmitted by the tubes through the output transformer to the modulator grids.

One precaution to observe in designing the filter is to make sure that the main capacitor pack does not use the container can as the negative terminal. If it does, the can will have to be insulated from the chassis to preserve separate electrical and mechanical grounds.

There is little need for good power supply regulation in this amplifier because the power tubes are operated in class A. Even at full signal, the total plate current rises only a few milliamperes; large voltage fluctuations are not therefore encountered.

The AMC Circuit

Provision for volume compression was incorporated in the amplifier because it can be quite beneficial when used with discretion. If the compression control is set so that the 6SR7 diodes begin to rectify at about 80% to 90% modulation, and if the volume control is advanced about 3 db higher than its normal position, the AMC circuit will help prevent overmodulation. If the time-delay circuit is not too slow, it may also increase the loudness of carelessly "swallowed" words, thereby improving to a certain extent the average intelligibility of transmitted signals.

A word of caution. Too much compression is readily possible. If the gain control is advanced more than 6 db and if the compression control is set so that rectification starts below the level of 75% modulation, an effect of blooping, burping, and gasping speech will be created. Words will start explo-
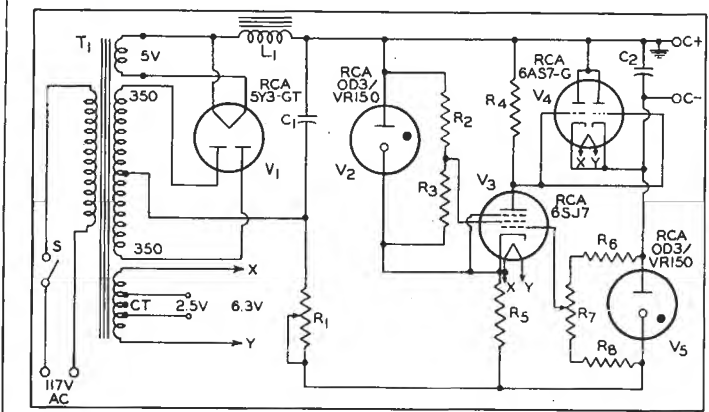
sively and end faintly. Furthermore, overmodulation will occur.

There is one special precaution to be taken in the compressor wiring. For best results, it is essential that a voltage of proper phase be delivered to the 6SR7 diodes, otherwise the gainshift "bloops" will be over-emphasized.

To get the right connection, disconnect bypass capacitor C6 and try the plate coupling capacitor C13 on first one and then the other 6AS7-G plate. One connection will cause some hum and a tendency to motor boat or howl. The other connection, the right one, may cause the amplifier to oscillate at some high frequency, but will tend to suppress any hum or low-frequency noises. It does this because it provides some inverse feedback at very low frequencies. With the time-constant capacitor C6 back in the circuit, the effect of the feedback is small, but beneficial.

The amplifier is so stable that the mechanical design layout is unimportant. As shown, this unit is built on a 12" x 3" x 7" chassis. On top of the chassis are the power transformer, interstage transformer, main capacitor pack, output transformer, and the tubes. The filter choke and other components are mounted underneath in convenient locations.

This new amplifier will deliver twelve watts of actual power output to a load at less than 4% distortion. This is adequate to drive any of the class B modulator tubes used in conjunction with a one-kilowatt final amplifier, with plenty of power to spare.

Fig. 2. Schematic of electronic bias supply.

PARTS LIST

R1	47000 ohms, ½ watt
R2	2 Meg., ½ watt
R3	1000 ohms, ½ watt
R4	120000 ohms, 1 watt
R5	680000 ohms, 1 watt
R6	220000 ohms, 1 watt
R7	33000 ohms, 2 watts
R8	500000 ohms, grid-taper pot
R9	47000 ohms, ½ watt
R10	390000 ohms, ½ watt
R11	2200 ohms, ½ watt
R12	560000 ohms, ½ watt
R13	150000 ohms, 1 watt
R14	270000 ohms, ½ watt
R15	82000 ohms, 1 watt
R16	50000 ohms, pot, wire-wound
R17	560000 ohms, ½ watt
R18	1200 ohms, ½ watt
R19	10000 ohms, 4 watts, wire-wound
R20	2500 ohms, 10 watts, wire-wound
R21	2500 ohms, 10 watts, wire-wound
R22	200 ohms, 10 watts, wire-wound
C1, C9	10 μf, 25 volts
C2	0.1 μf, 400 volts
C3	0.25 μf, 400 volts
C4,5,7,8	0.05 μf, 600 volts
C6	0.1 μf, 200 volts
C10	8 μf, 450 volts
C11,12	12 μf, 150 volts
C13	0.1 μf, 600 volts
C14,15	20 μf, 450 volts
T1	Thordarson T-20A22 or Stancor A-83-C
T2	Stancor A-4761, A4762, or equivalent
T3	Halldorson 74-S, or equivalent
L1	10 h at 125 ma

ELECTRONIC BIAS SUPPLY

directly to the plate of V3 and the grids of the output tube V4. This change in voltage swings the grid of V4 more positive or negative and thus varies the internal resistance of tube V4, maintaining the drop across it practically constant.

The unit shown in the schematic diagram will provide a regulated bias voltage adjustable from 30 to 80 volts, and will handle a rectified grid current up to approximately 200 ma. The unit can be adjusted down to 20 volts but at this voltage only about 100 ma can be handled. This voltage range covers the grid-bias requirements of nearly all the tubes used by Amateurs as class B modulators.

For those amateurs who are interested in the performance of the regulator the calculated voltage regulation is 0.001 volts/ma. This means that when the supply is set to, say, 45 volts a grid current of 200 ma through it will cause the bias voltage to rise to 45.2 volts. This change is so very small that it is not perceptible on the meter.

PARTS LIST

R1	5000 ohms, 25 watts, wire-wound
R2	24000 ohms, ½ watt
R3	68000 ohms, ½ watt
R4	270000 ohms, ½ watt
R5	3000 ohms, 5 watts, wire-wound
R6	120000 ohms, ½ watt
R7	100000 ohms, potentiometer
R8	27000 ohms, ½ watt
C1	20 μf, 450 volts
C2	20 μf, 150 volts
L1	8 h at 50 ma (ac/dc replacement choke)
T1	Thordarson T-13R20 or UTC R-11; 350-0-350 at 50 ma; 5 volts at 2 amps; 6.3 volts at 3 amps
S	Single pole, single throw toggle switch

The electronic bias supply shown above provides a regulated bias voltage adjustable from 30 to 80 volts and handles a rectified grid current up to 200 ma.

RCA-6AS7-G LOW MU TWIN POWER TRIODE

Amateur Net **$5.45**

Reduced To
$4.25

Features

- High Efficiency. Usable plate swing is almost equal to plate voltage.
- Good Stability. Low amplification factor insures freedom from regeneration.
- Two Cathodes. Allows use of self-bias balancing of the two triode units.
- Low Distortion. Even harmonics almost cancel in class A push-pull circuits.
- Excellent Voltage Regulation. Output signal varies but slightly with change in load.
- Twin-Unit Construction. Provides circuit layout convenience.
- In voltage regulator service, a load current of 250 ma can be controlled with one 6AS7-G. Because of the 300-volt heater-to-cathode rating, no separate filament winding is needed.
- In bias regulator service, the tube's low internal resistance allows regulation as low as 20 volts.

Application Considerations

The following recommended practices should be observed when the 6AS7-G is used in audio-frequency amplifier applications.

1. The two units should always be used in push-pull, never parallel.
2. Always use self bias; fixed bias must not be used.
3. Separate cathode bias resistors, and by-pass capacitors, should be used for each unit.
4. The total series grid resistance, per unit, should be limited to one megohm.
5. Transformer, or impedance-coupling devices should be used in order to get sufficient voltage to fully swing the grids.
6. The transformer-coupled driver tube should be a medium-mu triode such as the 6J5, 6SR7, 6C4, 6SN7, 12AU7, etc. For self-biased operation of the driver tube, by-pass its cathode resistor with a capacitance of 8 uf or more.
7. The plate supply voltage for the driver tube should be at least 250 volts in order to obtain sufficient grid swing for the 6AS7-G.
8. In a voice-frequency speech amplifier using a single driver tube, the plate of the driver tube can be series-fed through the primary winding of the interstage push-pull transformer.
9. In wide-band, flat-response, audio amplifier service, the grids can be excited by:
   (a) a push-pull stage through a high-fidelity push-pull interstage transformer.
   (b) a push-pull stage through a center-tapped plate choke, capacitance-coupled to resistor-fed grids.
   (c) a single tube with choke-fed plate, through a capacitance-coupled single-plate-to-push-pull-grids high-fidelity transformer.

6AS7-G LOW-MU TWIN POWER TRIODE
GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:*
Voltage ....6.3 ac or dc volts
Current ....2.5 amp.

Mechanical:

Mounting Position ....any
Maximum Overall Length ....5-5/16"
Maximum Seated Length ....4-3/4"
Maximum Diameter ....2-1/16"
Bulb ST-16
Base ....Medium Shell Octal 8-Pin

HAM TIPS is published by the RCA Tube Department, Harrison, N. J., and is made available to Amateurs and Radio Experimenters through RCA tube and parts distributors.

J. H. OWENS, W2FTW...*Editor*
H. S. STAMM, W2WCT....................................*Associate Editor*

AUDIO AMPLIFIER SERVICE
Values are for each unit

Maximum Ratings, Design Center Values:

PLATE VOLTAGE	250 max.	volts
PLATE CURRENT	125 max.	ma
PLATE DISSIPATION	13 max.	watts

PEAK HEATER-CATHODE VOLTAGE

Heater negative with respect to cathode	300 max.	volts
Heater positive with respect to cathode	300 max.	volts

Typical operation, Class A1 push-pull amplifier. Unless otherwise specified, values are for both units.

Plate	200	250	volts
Grid	-90	-125	volts
Cathode Resistor (per unit)	1500	2500	ohms
Peak AF grid to grid voltage	190	255	volts
Zero signal plate current	120	100	ma
Max. signal plate current	128	106	ma
Effective load resistance (plate to plate)	4000	6000	ohms
Total harmonic distortion (less than)	4	4	per cent
Max. signal power output	11	13	watts
Amplification Factor (per unit)	2.0	2.0	
Plate Resistance (per unit)	280	280	ohms

* It is essential that precaution be taken in equipment design to prevent subjecting the tube to full load current of 250 ma before its cathodes have reached normal operating temperature. The cathodes require approximately 15 seconds to attain normal operating temperature. Unless this precaution is observed, the cathodes will be seriously damaged, if not completely ruined. In speech amplifier service, as indicated under typical operating conditions, the plate voltage may be applied simultaneously with the filament voltage.

UNIQUE 'RAY GUN MONITOR CHECKS MODULATION QUALITY

'RAY GUN MONITOR
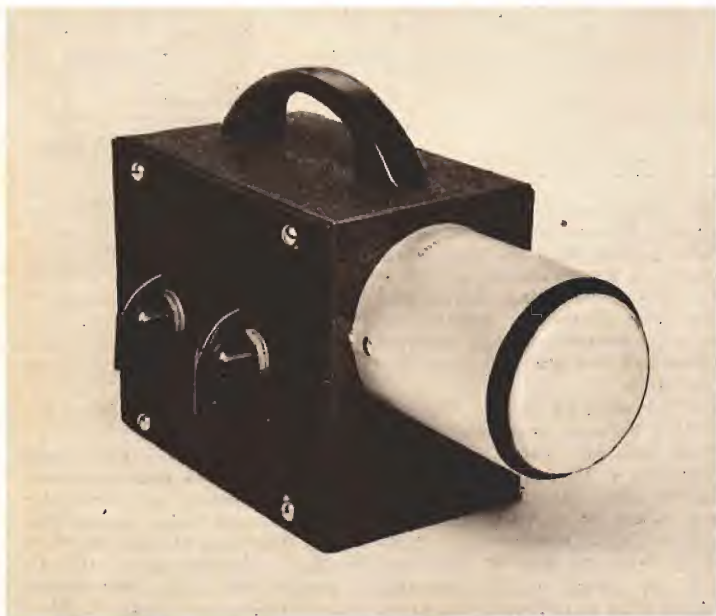
The unique unit shown above improves Ham 'phone technique by giving a positive visual indication of modulation quality. It's easy to build and can be made from a 2BP1 tube and a few inexpensive components

SIMPLE VISUAL MONITOR 'SCOPE EMPLOYS 2BP1 CATHODE-RAY TUBE

By J. H. Owens, W2FTW

If you would like to see your voice as others hear it, and if you would like to hear your station praised by those who can't see it, take this tip to check up on the quality of your modulation. It's so easy and so positive with the new RCA 'Ray-Gun Monitor.

The modern Amateur phone station transmits with a modulated signal comparable to that of a broadcasting station. In common use are the techniques of high-frequency pre-emphasis, band-width restriction, correct phasing of non-linear voice waves, automatic modulation control, clipper-filters, compression, harmonics suppression, and other very professional engineering practices. Of course, such advanced practices require the use of elaborate test and measuring equipment, but a great amount of progress can be made with a simple cathode-ray visual indicator such as the 'Ray-Gun Monitor.

Consisting of an RCA-2BP1 CR tube, a 3" x 4" x 5" cabinet, an 807 tube shield, with several resistors, capacitors, and pieces of wire, the unit can be put together in a few hours by the average ingenious Amateur. Reference to the circuit diagram will prove that there are fewer complications involved than would be encountered in the building of a "one-tube blooper".

The 'Ray-Gun Monitor is built without a power supply to provide portability, simplicity, and low cost. By means of flexible clip-lead cables it can be attached readily to almost any amateur transmitter. A pair of alligator clips are used for connecting a source of 6.3 volts to the heater. If the heater supply is not grounded, make sure that the peak heater-to-cathode voltage on the 2BP1 does not exceed ±125 volts. A larger battery-clip goes to the transmitter ground, which is also the negative high-voltage return. One of the insulated pee-wee (red) clips connects to the unmodulated high-voltage dc, and the other one (black) goes to the modulated high-voltage supply of the plate-modulated final amplifier. RF is fed into the unit through the

ANALYSIS OF CLASS B MODULATORS FOR AMATEUR 'PHONE APPLICATION

Brass-pounding may provide the basic interest in Amateur Radio, but "mike hounding" gives it the flavor of romance. Radiophone communication has the charm of reality—to hear the other fellow's voice as he hears yours—to speak half-way around the globe as if in person—this is a treat the whole family can enjoy.

If you haven't as yet tried 'phone, why not give it a fling? The cost is moderate, and the benefits can be very worthwhile. For instance, putting sound on your carrier will acquaint you with subjects of interest in radio-broadcasting, public address, and the other electronic arts and professions.

Where to start? Probably you are already familiar with microphone and speech amplifier circuits. The modulator is the final link in the radiophone chain, so a review of the theory and design practice of class B amplifiers is in order.

Basic Principles

A class B audio-frequency ampli-fier employs a pair of tubes, connected in push-pull, and biased near the point of plate-current cut-off, where the grid-voltage—plate-current characteristic starts to bend sharply. At low signal levels both tubes work together in complementary fashion, but at higher levels each tube alternately conducts and rests, and the resulting half-waves are combined in the modulation transformer to produce a composite wave which is an amplified replica of the original signal.

Objectives

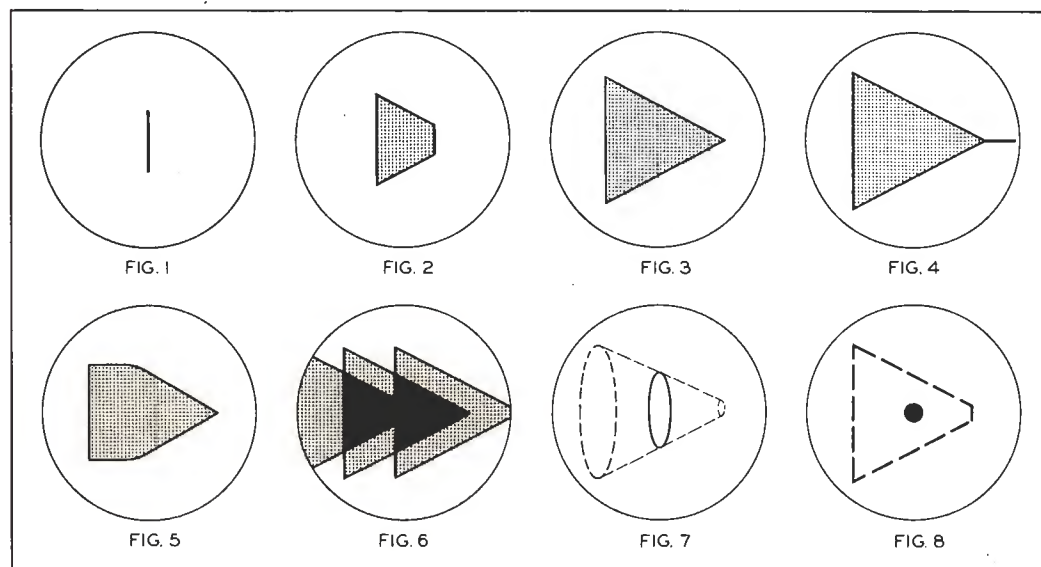One advantage of class B operation is that it provides high peak

AN INTERIOR VIEW
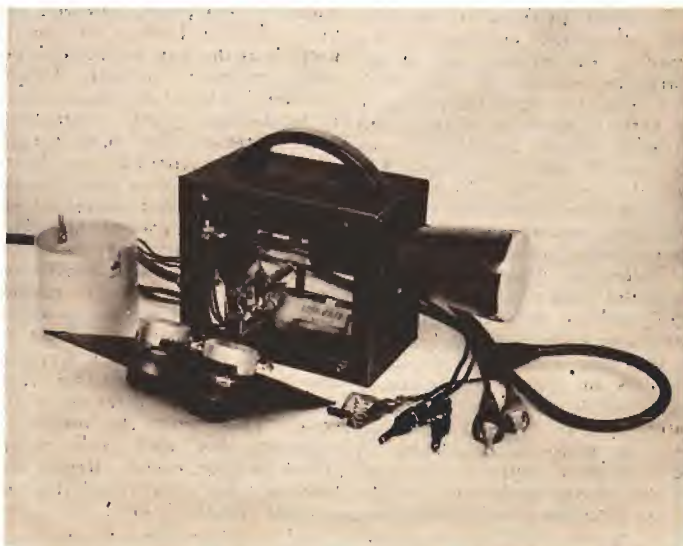
The 'Ray Gun Monitor with its cabinet cover removed shows a logical layout of wiring and parts. It requires no power supply.

'RAY GUN SCOPE VISUAL PATTERNS

FIG. 1   FIG. 2   FIG. 3   FIG. 4

FIG. 5   FIG. 6   FIG. 7   FIG. 8

#1. Unmodulated carrier. RF on vertical-deflection plates. No ac voltage on horizontal-deflection plates. Adjust rf coupling loop so that vertical line is about one-half inch long. A thickened line indicates hum or other noise on carrier.

#2. 50% modulated carrier. Left-end vertical line is 50% longer than unmodulated line of Fig. 1. Right-end vertical line is 50% shorter than the same unmodulated vertical line. Straight diagonal lines indicate linear modulation.

#3. 100% modulated carrier. Left-end vertical line is 100% longer than unmodulated line. Right-end vertical line is 100% shorter than unmodulated vertical line. Carrier shift is present when left-end vertical line is less than twice as long as unmodulated line. If unsymmetrical speech waves are properly phased, left-end vertical line may be more than twice as high as unmodulated line, and without distortion.

#4. Overmodulated carrier. Right-end spout indicates complete disappearance of carrier on negative peaks of modulation. Bad modulation splatter results due to generation of high-frequency audio harmonics.

#5. Downward modulated carrier. Final amplifier incapable of 100% positive-peak modulation. May be due to insufficient grid drive, too much fixed bias, insufficient grid-leak bias, or low emission of final tubes.

#6. Poor power supply voltage regulation. Because the monitor obtains its dc voltage from the high-voltage supply of the transmitter, a shift in dc plate supply voltage due to poor regulation develops a difference of potential between the two horizontal plates and thus produces a series of trapezoids.

#7. Unmodulated carrier. Ellipsoidal pattern indicates some out-of-phase rf on horizontal plates. Effect is as prominent at 150 Mc as illustrated in figure. Effect very slight at 30 Mc, and absent at 4 Mc. Dashed line indicates effect when carrier is modulated. Does not indicate distortion.

#8. Dc voltage on all electrodes, but no rf or af voltage on deflecting plates. Expanded spot indicates that deflection plates are picking up some stray rf and af voltages. 100% modulation can not reduce small end of trapezoidal pattern smaller than size of spot, as indicated by dashed line.

RAY GUN MONITOR

(Continued from Page 1, Column 4)

coaxial cable from the Faraday-shield pick-up loop. One of the knobs is a brightness control and the other one is for focusing the electron beam to a tiny spot.

The visual patterns produced by this cathode-ray oscilloscope are traced by the moving spot on the fluorescent screen of the 2BP1 tube. The spot scans the screen in the vertical direction as the result of the rf voltage impressed across one pair of deflecting plates. The spot also scans the screen in the horizontal direction as the result of the audio-frequency modulator voltage impressed across the other pair of deflecting plates. When the modulator causes this class C plate supply voltage to be increased, the spot moves horizontally to one side. At the same time, the rf output increases to supply an increased voltage across the vertical deflector plates of the 2BP1. Conversely, when the plate voltage supply of the modulated amplifier decreases, the spot moves horizontally in the reverse direction. At the same time, the rf output decreases to supply

a reduced voltage across the vertical-deflection plates of the 2BP1. The result is that the spot forms a trapezoid.

Construction

The utter simplicity of the 'Ray-Gun Monitor precludes a discussion of the details of fabrication. There is one point, however, that might deserve further mention inasmuch as the unit is not equipped with centering controls. Cutting and drilling the steel cabinet causes it to become partly magnetized, and, therefore, the small amount of residual magnetism may deflect the electron beam so that the spot is not in the exact center of the tube screen. To correct this condition it is only necessary to neutralize the effect of the small magnetic field produced by the cabinet. Take a horseshoe magnet, or an old PM speaker, and move it about the closed cabinet in such a way that the spot is forced further from center in the same direction as the error. Then when the magnet is removed, the spot will return closer to exact center. Repeat this process a few times until the spot is right "on the beam".

(Continued on Page 4, Column 1)

CAUTION

Because of the high voltages present in Ham transmitters, Amateurs must exercise special care when connecting the 'Ray-Gun Monitor to their rigs. Always turn off all power from the transmitter and make sure that all filter condensers are completely discharged before making any clip lead connections. It's better to be safe than sorry!
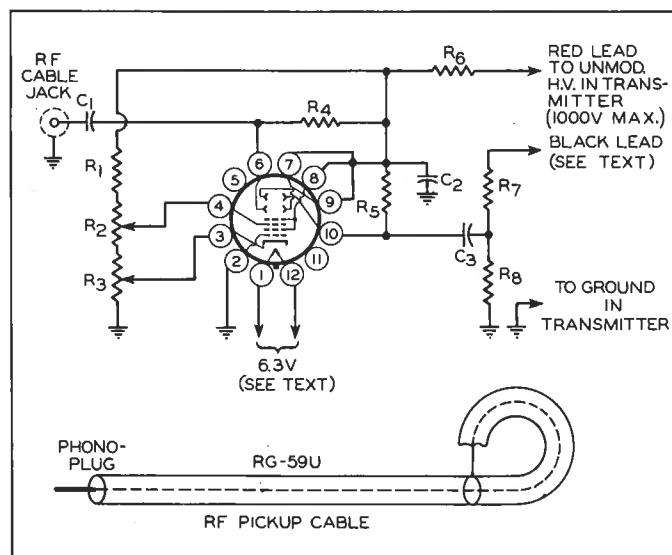
Schematic diagram of 'Ray Gun Monitor. Connections to base pins 9 and 10 may be interchanged to reverse the pattern horizontally.

CLASS B MODULATORS

(Continued from Page 1, Column 2)

output power with respect to the no-signal input power. In the quiescent "no signal" condition, audio amplifier tubes dissipate all of the power delivered to them. As a result, if high plate voltages are used, the quiescent plate current must be kept low in order that dissipation ratings will not be exceeded under the no-signal condition.

Good plate circuit efficiency is another characteristic of class B audio amplifiers. One reason is that when the input signal level becomes appreciable, all of the plate current becomes signal plate current. Also, as a result of the grids being driven positive, the plate voltage swings all the way to the diode line on peak positive grid excursions and the peak values of plate current are, therefore, much higher than would be obtained under class A, AB, or AB₂ conditions. In the case of high-perveance tubes like RCA-811's, the voltage at the diode line is small, thus providing an efficiency factor approaching the theoretical maximum of 78.5% which would exist if the plate swing equalled the plate-supply voltage, as shown by the formula:

$$\text{Plate efficiency} = \frac{\pi}{4}\left(1 - \frac{E\min}{Eb}\right)100$$

Where E min is plate voltage at diode point and E_b is the plate-supply voltage. If E min is taken as zero, the plate efficiency is equal to 78.5%.

In a practical circuit, using a pair of RCA-811's at 1500 volts and a load line of 4400 ohms (17,600 ohms plate-to-plate), the voltage at the plates (E min) would be pulled down to 70 volts on maximum signal peaks. Under these conditions, the efficiency formula would give the following results:

$$\text{Plate eff.} = \frac{\pi}{4}\left(1 - \frac{E\min}{Eb}\right)100 =$$

0.785　(1 − (70 ÷ 1500))　100 =
0.785 x 0.954 x 100 = 75%

This formula holds for pure sine-wave signals only, and does not take into account transformer losses. If considerable harmonic distortion is allowed, the efficiency can be slightly higher, but such distorted power output should not be credited as useful power output. Reputable tube manufacturers indicate conservative values of tube power output from which it is only necessary to deduct transformer losses to obtain actual amplifier power output.

Typical Operation

Although tube handbooks provide tables of typical operating data, it is frequently desirable to establish a set of conditions for a particular application that has not been previously used as an example. To illustrate the procedure, consider the combination of a 1500 volt dc power supply and a pair of 811's, but the need for only 140 watts of audio power.

To be on the safe side and provide for a slightly higher than normal amount of circuit and component losses, a conservative efficiency factor of 70% should be used. The required plate power input to a class B amplifier (Pᵢₙ) can then be determined from its relation to the desired power output (P₀):

$$P_{in} = \frac{P_o}{0.7} = 140 \div 0.7 = 200 \text{ watts}$$

The total dc plate current (I_b) at maximum signal, with a plate-supply voltage (E_b) of 1500 then becomes

$$I_b = \frac{P_{in}}{E_b} = 200 \div 1500 = 133 \text{ ma}$$

The next step is to determine the peak value of signal plate current per tube (I_p):

$$I_p = \frac{\pi I_b}{2} = 1.57 \times 133 = 210 \text{ ma}$$

Reference to the plate family will show that 210 ma is located on the diode line at approximately 50 volts. This means that the plate swings from 1500 down to 50 volts on peak positive grid excursions, and provides a peak plate swing (E_p) of 1450 volts. The load line can now be drawn as a straight line between 1500 volts at zero plate current (E_b) and the point of intersection of 210 ma (I_p) and 50 volts (E min). The load resistance (R_L) represented by this line can be calculated as follows:

$$R_L = \frac{E_p}{I_p} = \frac{1450}{0.210} = 6900 \text{ ohms}$$

The equivalent plate-to-plate load impedance is four times the plate load per tube, or 27,600 ohms. This value of effective load resistance is optimum for the conditions set up in the problem. If a lower value is used, more power output can be obtained but the efficiency will be slightly lower. Any difference in distortion is negligible. Plate power output for a class B amplifier can now be calculated from the formula:

$$P_o = \frac{I_p (E_b - E\min)}{2} =$$
$$\frac{0.210 (1500 - 50)}{2} = 152 \text{ watts}$$

This is more than the required 140 watts and provides ample safety factor for higher than normal circuit and component losses.

Grid-Circuit Conditions

The exact value of negative grid bias (E_c) needed is not critical. A satisfactory approximation can be obtained by dividing the plate-supply voltage by the tubes' amplification factor. In the case of 811's, which have a mu of 160, the value obtained is −9.5 volts. This value would be exact cutoff if the grid-voltage/plate-current characteristic were a straight line. In practice, this theoretical cutoff voltage is very near to the optimum bias voltage.

At plate potentials of 1250 volts or less, the 811's will operate within plate dissipation ratings without any negative grid bias. Because of this feature, they are called "zero bias modulators". High-mu tubes can be used without negative

A FAMOUS PAIR—RCA-811'S

These transmitting triodes have long been the Amateurs' favorite class B modulators.

grid bias when the product of plate voltage and quiescent plate current is less than the tubes' dissipation ratings.

Again, referring to the plate family, it will be seen that a peak plate current of 210 ma is drawn at 50 plate volts when the grid goes approximately 55 volts positive. The peak a f cathode-to-grid voltage (E_g) will be 55 plus the bias voltage or close to 64 volts. To determine the grid driving power of a class B amplifier, refer to the plate family of curves and note the peak value of grid current (I_g) that flows when the plate voltage is minimum (50 volts) and when the grid voltage is at the crest of its cycle (+ 55 volts). It will be seen to be 70 ma. Grid driving power for two tubes (W_g) can now be ascertained by solving the equation:

$$W_g = \frac{I_g (E_g + E_c)}{2} =$$
$$\frac{0.07 \times 64}{2} = 2.24 \text{ watts}$$

The minimum effective resistance (R_g) of one modulator tube grid can also be determined for impedance-matching purposes. The formula is

$$R_g = \frac{E_g + E_c}{I_g} = \frac{64}{0.07} = 915 \text{ ohms}$$

Audio Power Requirements

The ratio of power input to the final amplifier and audio power output from the modulator is usually stated as 2 to 1 for 100% plate modulation. This ratio holds true only when sine-wave modulation is used, since it is based upon the relationship of voltages.

To illustrate with an example, consider a 100-watt class C amplifier drawing 100-ma from a 1000-volt plate supply. 100% modulation requires that the plate voltage be alternately doubled and reduced
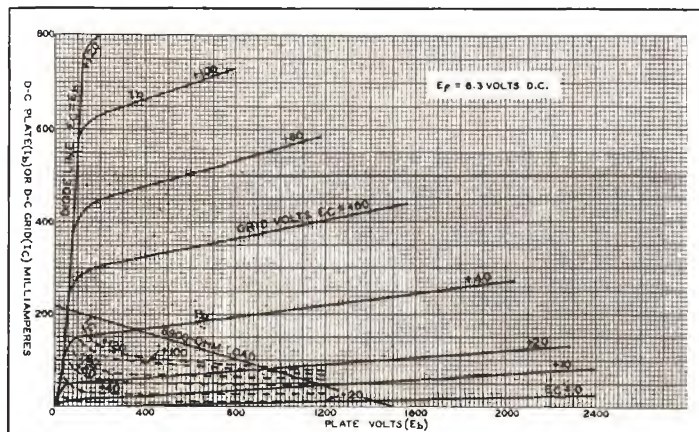
Average plate characteristics of the 811. Note that emission capabilities far exceed class B amplifier requirements.

RCA 2BP1 2" OSCILLOGRAPH TUBE

2BP1 OSCILLOGRAPH TUBE 2"—Diameter Bulb

DATA

Amateur Net $8.75

General:

Heater, for Unipotential Cathode:

Voltage (AC or DC)	6.3 Volts
Current	0.6 Ampere
Phosphor	No. 1
Fluorescence	Green
Persistence	Medium
Focusing Method	Electrostatic
Deflection Method	Electrostatic
Base	Small-Shell Duodecal 12-Pin
Mounting Position	Any

Maximum Ratings, Design-Center Values:

ANODE- No. 2 & GRID-No. 2 VOLTAGE	2500 max.	Volts
ANODE-No. 1 VOLTAGE	1000 max.	Volts

GRID-No. 1 VOLTAGE:

Negative bias value	200 max.	Volts
Positive bias value	2 max.	Volts

PEAK VOLTAGE BETWEEN ANODE No. 2 AND

ANY DEFLECTING ELECTRODE	500 max.	Volts

PEAK HEATER-CATHODE VOLTAGE:

Heater negative with respect to cathode	125 max.	Volts
Heater positive with respect to cathode	125 max.	Volts

Equipment Design Ranges:

For any anode No. 2 voltage (Eb2) between 500 and 2500 volts

Anode-No. 1 Voltage	15% to 28% of Eb2	Volts
Grid-No. 1 Voltage for Visual Cutoff	0% to 6.75% of Eb2	Volts
Anode-No. 1 Current for Any Operating Condition	−15 to +10	Microamp.

Deflection Factors:

DJ1 & DJ2	115 to 155 V dc/in./Kv of Eb2
DJ3 & DJ4	74 to 100 V dc/in./Kv of Eb2

Examples of Use of Design Ranges:

For anode-No. 2 voltage of	1000	2000	Volts
Anode-No. 1 Voltage	150-280	300-560	Volts
Grid-No. 1 Voltage for Visual Cutoff	0-67.5	0-135	Volts

Deflection Factors:

DJ1 & DJ2	115-155	230-310	Volts dc/in.
DJ3 & DJ4	74-100	148-200	Volts dc/in.

Maximum Circuit Values:

Grid-No. 1-Circuit Resistance	1.5 max.	Megohms
Resistance in Any Deflecting-Electrode Circuit	5.0 max.	Megohms

Features

- High deflection sensitivity
- Good sensitivity to 150 Mc
- Sharp focus over entire screen
- Improved electron-gun with zero-current first anode
- Operates with a plate supply of only 500 volts
- Individual base-pins for all deflecting electrodes

Application Considerations

1. Focus of the electron beam is accomplished by the adjustment of anode #1 voltage with respect to anode #2 voltage.
2. Spot centering may be obtained electro-magnetically or electro-statically. If the latter is used, it may be necessary to apply to adjacent deflecting plates a voltage difference as high as 2% of the dc voltage on anode #2.
3. Brightness may be increased by a reduction of the negative bias on grid #1, or by an increase of the positive voltage on anode #2.
4. For best results, anode #2 voltage should be 500 volts or higher. 1000 volts provides a brilliant trace that is clearly visible in a well-lighted room.
5. An oscillograph circuit in a 12-page technical bulletin is available on request. Write to RCA, Commercial Engineering, Harrison, N. J.

RAY GUN MONITOR

Application

The 'Ray-Gun Monitor can also be used to show a wave-form pattern. In this use, the modulated dc voltage on the horizontal deflecting plate should be replaced with 60-cycle ac. This change can be made by connecting the clip of the horizontal deflection lead to the plate of one of the high-voltage rectifier tubes.

The 'Ray-Gun Monitor is designed for use with transmitters operating at plate voltages up to about 1000 volts. The limitation is the working voltages of the various capacitors. When the Monitor is used with higher-voltage rigs, bleeders will have to be used to reduce the voltages to which the clip-leads are attached to not over 1000 volts. The bleeders can be made up of 1-megohm, 1-watt carbon resistors. These resistors should be permanently wired in the transmitters so that the 'Ray-Gun Monitor can always be put to work in a few seconds.

CLASS B MODULATORS

to zero. This would require an alternating peak voltage of 1000 volts, or an RMS voltage of $1000 \div \sqrt{2}$ or 707 volts. The 1000-volt, 100-ma class C amplifier load appears to the modulator as a pure resistance of 10,000 ohms as determined from the relationship:

$$R = \frac{E_b}{I_b} = \frac{1000}{0.1} = 10,000 \text{ ohms}$$

The sine-wave power required to develop 707 RMS volts across 10,000 ohms can be determined from the formula:

$$\text{Watts} = \frac{E^2}{R} = 707^2 \div 10,000 = 50$$

If the modulating signal were a square wave, 1000 volts would still be required for 100% modulation. But in this case, the average voltage would equal the peak voltage, therefore 100 watts of square-wave audio would be required to plate-modulate 100 watts of power input to the final amplifier. This condition is almost reached when a "clipter" is used and adjusted for maximum clipping and filtering.

When voice modulation is used, the condition is again different, although 1000 peak volts of audio power is still required. The RMS voltage of an average speech wave is less than half the peak voltage. If a figure of 50% is used, for example, the RMS modulating potential would be 500 volts, and the modulation power would be $500^2 \div 10,000$ or 25 watts. This is why some Amateurs figure on a 4 to 1 ratio of class C input to modulator power output.

On the above basis a pair of 811's would be capable of modulating 880 watts input to a final amplifier. However, to get the 1000 peak volts for 100% modulation, the turns ratio between primary and secondary of the modulation transformer has to be reduced. As a result, the transformer reflects a lower than proper load impedance to the modulator plates. Under these conditions, the class B modulator tubes can be quickly overloaded by a sine-wave signal from a test oscillator, or a whistle, or a soft female voice—and we should never do anything that might possibly keep those purring YL's and XYL's out of our Ham Shacks.

DELUXE TRANSMITTER USES PAIR OF 812-A TUBES IN FINAL

TURN DOWN THE GAIN CONTROLS!

This easily-built pre-amplifier unit greatly increases signal strength and improves receiver sensitivity on the popular 2 meter band.

LOW-NOISE BROAD-BAND PRE-AMPLIFIER DESIGNED FOR 2-METER RECEIVERS

By E. M. Brown, W2PAU and J. T. Blake, W2PFQ

Engineering Products Department, RCA

In the two-meter band, one of the best ways to improve receiver sensitivity is to add a properly designed pre-amplifier. The one described in this article will increase the signal strength two to three points on the "S" meter of a receiver and has such a high signal-to-noise ratio, that its performance is limited only by antenna noise.

The pre-amplifier is inserted in a 300-ohm feeder, between the antenna and the regular two-meter receiver. The unit has a broad-band response so that only an occasional touch-up of the tuning is necessary.

Design Considerations

On the low-frequency bands, the limit of useful receiver gain is set by QRN, man-made or natural. Signal-to-noise ratio is of minor significance and the features usually considered for determining the merit of a low-frequency receiver include such factors as bandwidth of if stages, audio response, ease of tuning, and image rejection.

On the vhf bands, atmospheric noise is practically non-existent. Man-made noise may be troublesome, but in most locations it is a minor problem. The noise which limits the performance of an ideal vhf receiver, however, is the thermal noise generated by the antenna. The thermal noise across a 300-ohm input line is equivalent to about 0.2 microvolts in a good communications-type receiver having an if band-pass of 10 kilocycles. If a gain of 5 can be ob- tained from a "quiet" rf pre-amplifier, the 0.2 microvolts of thermal noise can be detected by a receiving system including the pre-amplifier and a receiver capable of detecting a one-microvolt signal.

Circuit Selection

If the proper circuit is chosen, considerable reduction in tube noise generated within the amplifier stage can be achieved. Since triodes generate less noise than pentodes, it is well to consider utilizing a triode in the rf stage. Triodes in push-pull were selected for the pre-amplifier because such a circuit permits the use of a step-up antenna transformer and takes advantage of the full gain of the triode stage.

Of course, the triodes have to be neutralized but the new miniature tubes and components that are now available permit such compact circuit layouts that nearly perfect neutralization is easy to achieve. The push-pull connection reduces the input capacitance by 50% which makes for a broadly resonant, high-inductance circuit.

The RCA-6J6 twin triode was selected for this pre-amplifier chiefly

COMPACT 6-BAND 1/2-KW RIG HAS SIMPLE BAND-SWITCHING EXCITER

By Geo. H. Jones, Jr., W2CBL

This easy-to-build transmitter works as nice as it looks, on 10, 11, 15, 20, 40, or 80, with a full ½-kw input to a pair of RCA-812-A's from a 1500-volt power supply. The new 812-A handles more power and is better than the superseded 812; which makes it an attractive choice for this flexible rig. The transmitter is built on a 17"x13"x3" chassis, with a standard rack-mounting 19"x12¼" panel. The power supplies and modulator, not illustrated, are of similar construction, and are mounted in a standard 3½-foot relay rack.

Panel, chassis, and shields are constructed of aluminum to minimize rf losses, since the circuit components are compactly assembled. The layout of rf components follows in the same order as in the schematic diagram, Fig. 1, starting with the 80-meter crystals and proceeding counterclockwise to the 812-A's.

Fairly high screen and grid-biasing resistors are used in the crystal-oscillator circuit to facilitate doubling when an external vfo is used. A 560-ohm cathode resistor limits the non-oscillating plate and screen currents to a low value. Crystals X_1 and X_2 operate near the edge of the 80-meter band and can be used as band-limit markers when adjusting the vfo.

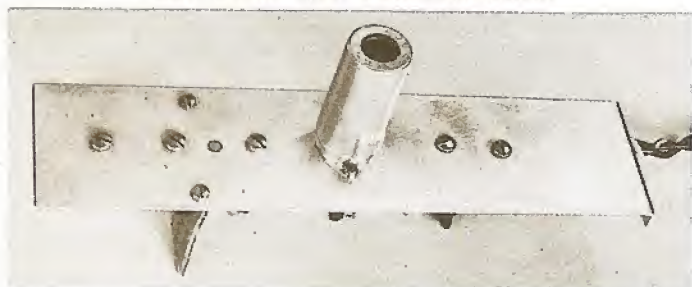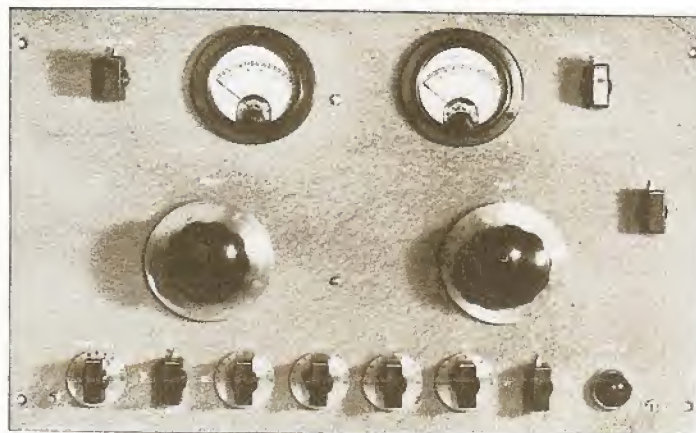The first multiplier grid is tapped down about 1/3 from the plate end of L_1 to provide proper excitation to the following multiplier grid. A three-turn link, switched through S_2, gives ample coupling to the 807 grid tank L_5. For 80-meter operation, S_2 couples the oscillator output to the 807 grid circuit and removes plate voltage from the three multiplier stages. L_1C_5 tunes sufficiently below 3500 kc to provide excitation for the 11-meter band when multiplying eight times.

Approximately 3 milliamperes of grid drive are supplied to the first multiplier stage by the crystal oscillator, and about 10 milliamperes are delivered to the 807's.

Tank L_2C_{10} of the first multiplier stage covers double the frequency range of the crystal stage. This first multiplier drives the second multiplier through C_{11}; or, with S_2 in the "40" position, the first multiplier drives the 807's through link coupled to L_2. Grid drive to the 807's on the 40-meter band is

BUSINESS-LIKE AND EFFICIENT

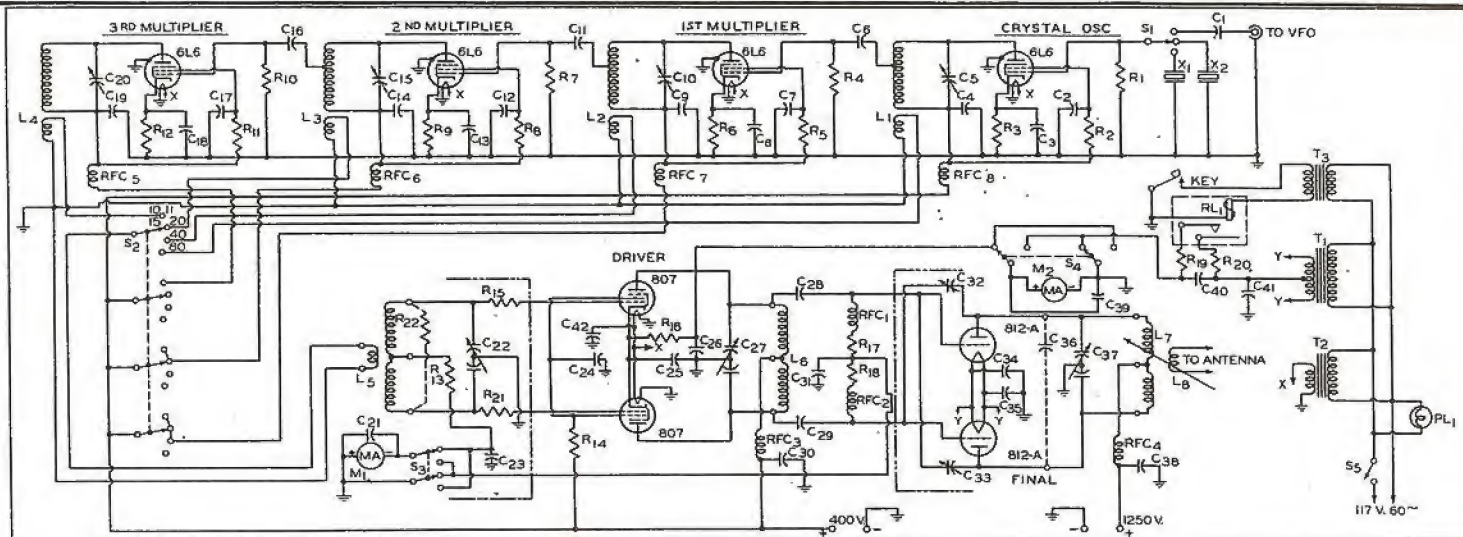*The efficient manner in which this versatile rig was designed and constructed is reflected in its panel symmetry.*

Figure 1. Schematic of the 6-band transmitter.

COMPACT 6-BAND RIG

(Continued from Page 1, Column 4)

practically the same as when operating directly from the crystal oscillator on the 80-meter band.

For 20-meter operation, L_2C_{13} is tuned to four times the oscillator frequency; for 15-meter work L_2C_{13} is tuned to six times the oscillator frequency. Equal excitation (10 milliamperes) is delivered to the 807 grids when doubling or tripling. With S_2 in the "15-20" position, plate voltage is applied to the second multiplier and the link-coupling circuit is completed between L_3 and L_5.

The third multiplier tank L_4C_{20} covers a frequency range eight times that of the crystal stage, and supplies 10- and 11-meter drive (10 milliamperes) to the 807's when S_2 is in the "10-11" position.

Circuit Symmetry

Suitable values of L_5 must be plugged-in to operate on the various bands. On 80, 40, and 20, it was found desirable to shunt L_5 with the 20,000-ohm resistor R_{22} for suppression of normal-frequency parasitics. No shunting resistor is needed for the 10-meter coil. The 33-ohm resistors R_{15} and R_{21} are parasitic-oscillation suppressors and are mounted as closely to the socket pins as possible.

The 807 stage was laid out with considerations of circuit symmetry and good shielding between plate- and grid-tank circuits, since this stage operates at all times with grid and plate circuits at the same frequency. Two 807's are used to provide push-pull excitation to the 812's with simple circuit means. Plug-in coils are used in the grid and plate circuits of this stage. Standard B&W coils cover the 80-, 40-, and 20-meter ranges, but the plate coil required modification for the 10-meter band. For 10-meter operation, L_5 is a 6-turn coil $1\frac{1}{4}$ inches in diameter, wound 3 turns per inch with No. 10 wire.

Due to effective shielding and layout, the 812-A final is stable when neutralized. The stage is neutralized with the transmitter adjusted for 10-meter operation. Once C_{32} and C_{33} are set, no further adjustment is necessary when other plug-in coils are used.

Standard B&W coils for the 812-A final were found satisfactory for operation on the 10-, 20-, and 40-meter bands, but the 80-meter coil required modification. Four turns were removed from each outside end of this coil to obtain an improved L/C ratio. Plug-in capacitor C_{36} is a fixed padding capacitor which is used only for 80-meter operation; it is removed when shifting to higher frequency bands. Grid drive to the final (read on M_1) runs 50 to 60 milliamperes under full plate power input to the final.

Filament center-tap keying is used because it gives clean keying and because the transmitter is completely self-biased. With key up, the filament circuit may rise to a maximum of 480 volts above ground. C_{40}, R_{19}, and R_{20} comprise a filter which materially reduces key clicks.

The plate-power requirements are simple: a 400-volt, 200-milliampere supply for the crystal oscillator, multiplier stages, and the push-pull 807 driver stage; and a 1500-volt, 350-milliampere supply for the 812-A final stage will fill the bill.

No special tools or fittings are required for construction of the transmitter. Shielding construction is all of flat aluminum with no forming other than right-angle bends for mounting to the chassis and panel.

The plate-circuit components and tubes for the driver stage are above and on the left-hand front portion of the chassis. The final 812-A tubes are mounted in a horizontal position through the inter-stage shield between the 807 and final stages, with the filaments in a vertical plane. The neutralizing capacitors and plate-circuit components for the final stage are on the front right-hand portion of the chassis. This layout affords short and direct coupling from stage to stage and allows front-panel controls to be brought out in a symmetrical arrangement.

Metering and switching is provided for reading grid current to the 807 or 812-A stages on one meter, and cathode or total tube current on another meter. This metering is ample for complete tuning of the transmitter on all bands and keeps the meters at ground potential.

Shock Proof Panel

One important feature of the transmitter is its shock-proof front panel. One terminal of each meter is bonded to the panel. The two final-stage tank-tuning capacitors are mechanically grounded, and all switch shafts are grounded metal. The oscillator-, multiplier-, and antenna-coupling shafts are insulated, but pass through grounded $\frac{1}{4}$-inch bushings at the front panel.

There are four small inter-shield panels, all made of 1/16-inch aluminum. One of these is mounted under the chassis 4 inches from the rear edge. The crystal oscillator is mounted on this shield, in addition to three multiplier tuning capacitors and switches S_1 and S_2. A second inter-shield is mounted above the chassis just to the left of center, separating the 807 and 812-A stages. Two other small shields are used to box off the 807 grid coil and shield it from the 807 plate coil.

Mounting of other parts is evident from the illustrations. Besides the four inter-stage shields, there are two rear support brackets for the 807 and 812-A plate-tuning capacitors. A lucite panel is used to insulate the crystal-oscillator and multiplier tuning capacitors. Three-quarter inch holes were first punched in the under-chassis shield for the four capacitors; the lucite strip was then mounted behind this

A "BALCONY" VIEW
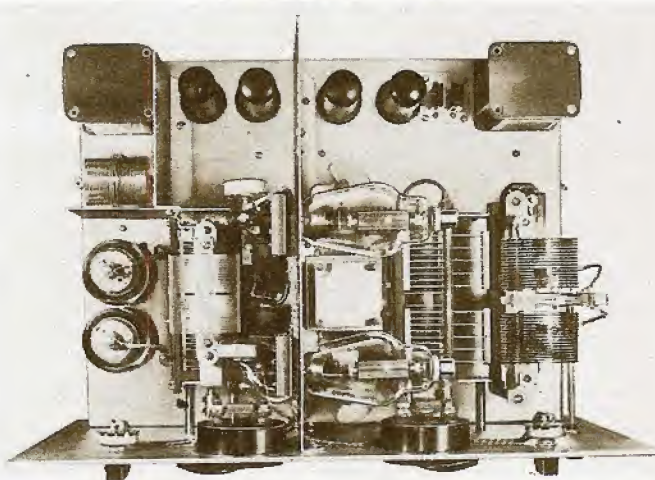
Good shielding between plate and grid-tank circuits was incorporated in the compact $\frac{1}{2}$ kw rig.

shield and shaft-bushing clearance holes were drilled concentric with the ¾-inch holes for the tuning capacitors.

Band switch S_2 was partially disassembled and the rf-link switching section was reassembled behind the under-chassis shield panel. The crystal switch S_1 is mounted behind this panel on the left-hand end. This switch is wired to a coaxial connector on the chassis so that excitation from an external vfo can be brought to the transmitter. When using an external vfo, its frequency should be one-half that of the normal crystal frequencies; the 80-meter stage is then used as a doubler and operates the same as the other multiplier stages in the transmitter.

Cabinet Considerations

All parts can be mounted before wiring with the exception of the tank coils, the links for the crystal oscillator, and three multiplier stages, and the tuning capacitor C_{22} for the 807 stage. With these parts out, all socket lugs and wiring points are accessible for wiring.

A transmitter of these voltage and power requirements should be completely encased in a grounded metal cabinet for elimination of shock hazard. The metal cabinet also helps to reduce harmonic radiation and television interference. (See page 166 of the ARRL Handbook, 1948 edition.) If ventilating louvers are used, they should be covered completely with close-meshed screening on the inside of the cabinet.

Tuning of the transmitter is simple, once the operator becomes acquainted with the controls. A change from band to band can be made in less than two minutes.

The first tune-up should be made on 80 meters. With the 80-meter coils plugged into positions L_5, L_6, L_7, with C_{36} inserted and S_2 turned

to the "80" position, the unit is ready for tuning. Oscillator tuning control C_5 is tuned until a change in 807 cathode current (read on M_2) is noted. This change indicates that the crystal is oscillating. C_{22} is then tuned to resonance to give maximum grid drive to the 807 stage (read on M_1 with S_3 in the proper position). *C A U T I O N: When the final tank is out of resonance, excessive plate dissipation must be avoided by reducing the plate voltage, or by tapping the key rapidly.*

Tuning Details

The plate circuit of the 807 stage is then tuned to resonance (indicated by minimum current as read on M_2). The 812-A final stage should next be neutralized. With the plate voltage off, and key down, C_{32} and C_{33} are adjusted until there is no dip in the final grid current when tuning the final tank capacitor C_{37} through resonance. The final grid current (read on M_1 with S_3 in the proper position) will be approximately 75 milliamperes with plate voltage to the stage off. This current will fall to approximately 60 milliamperes with plate voltage and full loading applied.

The transmitter is next tuned up on 40 meters. Coils L_5, L_6, L_7 are changed, and C_{36} is removed. (Note that C_{36} is left out on all bands except 80 meters.) Band switch S_2 is changed to the "40" position. C_5 is left unchanged, and with the crystal stage oscillating as tuned for 80 meters, C_{10} is next tuned until a change is noted in the 807 cathode current, as observed when tuning-up on "80". After this current change is noted, tune-up the 807 and 812-A stages as explained for "80". C_{32} and C_{33} should not need adjustment if properly set in the first tune-up.

Tuning on 20 or 15 meters follows next. Proper coils are in-

serted at L_5, L_6, L_7, and S_2 is turned to the "15-20" position. C_5 and C_{10} are unchanged, and 40-meter drive is supplied to the grid of the 15-20 meter multiplier stage. C_{15} will give two indications of resonance: the first point, at double frequency of the previous multiplier, occurs when C_{15} is adjusted to nearly full capacitance, and supplies 20-meter drive to the 807 grids. The second point occurs near minimum capacitance of C_{15}, and provides 15-meter drive to the 807 grids. Tuning of the 807 and 812-A stages is accomplished as before.

Tune-up on 10 or 11 meters as follows: insert the proper coils at L_5, L_6, L_7. Turn S_2 to the "10-11" position. Leaving C_5, C_{10}, and C_{15} set for 20-meter operation, C_{20} is then tuned for a current change in the 807 cathode circuit as explained above. The 807 and 812-A stages are tuned as before.

Note that the frequency coverage of $L_4 C_{20}$ does not include 7.5 meters, so that if the tuning of the 15-20 meter multiplier is set at 15 meters, no resonance point will be found for the 10-11 multiplier.

Once the transmitter has been tuned up on the various bands, approximate settings of all controls will be known, and changing from band to band will become a simple operation.

NOW—A BETTER TRIODE

The new RCA-812-A is easy to drive, and easy on the pocketbook. A pair in class B can deliver 340 watts of audio at 1500 plate volts (ICAS rating). A single 812-A will handle an input of 260 watts (ICAS rating) in class C telegraphy up to 30 Mc. At $3.75, it's an excellent buy in its class.

A "BOTTOMS UP" VIEW

The logical placement of components and wiring on a 17"x13"x3" chassis was a major consideration in the transmitter's design.

PARTS LIST

C_1 C_6 C_{11} C_{16} = 0.0001 µf, mica, 500 working volts

C_2 C_3 C_4 C_7 C_8 C_9 C_{12} C_{13} C_{14} C_{17} C_{18} C_{19} C_{23} C_{24} C_{25} C_{26} C_{30} C_{31} C_{42} = 0.005 µf, mica, 500 working volts

C_{21} C_{39} = 0.01 µf, mica, 300 working volts

C_{28} C_{29} = 0.0001 µf, mica, 1200 working volts

C_{34} C_{41} C_{12} = 0.002 µf, mica, 500 working volts

C_{35} = 0.002 µf, mica, 3000 working volts

C_{40} = 0.05 µf, oil-filled paper, 500 working volts

C_5 = ZU140AS Cardwell Trim-air capacitor

C_{10} C_{15} = ZU75AS Cardwell Trim-air capacitors

C_{20} = ZR25AS Cardwell Trim-air capacitor

C_{22} = EU100AD Cardwell capacitor

C_{27} = MT100GD Cardwell capacitor

C_{32} C_{33} = NA10NS Cardwell capacitor

C_{36} = JCO-50-OS Cardwell capacitor

C_{37} = XG-50-XD Cardwell capacitor

R_1 R_4 R_7 R_{10} = 47,000 ohms, carbon, 1 watt

R_2 R_5 R_8 R_{11} = 47,000 ohms, carbon, 2 watts

R_3 R_6 R_9 R_{12} = 560 ohms, carbon, 2 watts

R_{13} = 10,000 ohms, carbon, 10 watts

R_{14} = 15,000 ohms, carbon, 10 watts

R_{15} R_{21} = 33 ohms, carbon, 1 watt

R_{16} = 250 ohms, 10 watts

R_{17} R_{18} = 5000 ohms, 10 watts

R_{19} R_{20} = 50 ohms, 10 watts

R_{22}* = 20,000 ohms, carbon, 1 watt

M_1 = Weston 301, 150 milliamperes

M_2 = Weston 301, 500 milliamperes

L_1 = B & W Miniductor No. 3016; 35 turns wound 32 turns per inch, 1" diameter, tapped at 10 turns from plate end; 3-turn link spaced ⅛" from ground end

L_2 = B & W Miniductor No. 3015; 22 turns wound 16 turns per inch, 1" diameter, tapped at 7 turns from plate end; 3-turn link spaced ⅛" from ground end

L_3 = B & W Miniductor No. 3014; 10 turns wound 8 turns per inch, 1" diameter, tapped at 3 turns from plate end; 3-turn link spaced ⅛" from ground end

L_4 = B & W Miniductor No. 3014; 7 turns wound 8 turns per inch, 1" diameter; 3-turn link spaced ⅛" from ground end

L_5 = B&W Type JCL; 5-pin socket mounting

L_6 = B&W Type B; center-tapped coil without link

L_7 = B&W Type TVL, variable linked, center-tapped

L_8 = B&W swinging link and base for TVL coils

T_1 = Filament Transformer, 2.5 volts, 5 amperes

T_2 = Filament Transformer, 6.3 volts, 8 amperes

T_3 = Filament Transformer, 6.3 volts, 8 amperes

S_1 = Mallory Hamband Switch, 4 pole, 1 section

S_2 = Mallory Hamband Switch, 4 pole, 4 section

S_3 S_4 = Shorting-type Switches, 2 pole, 2 section

S_5 = SPST Switch

RFC_1 RFC_2 RFC_5 RFC_6 RFC_7 RFC_8 = National Type R-100 Chokes, 2.5 millihenries

RFC_3 = National Type R-300 Choke

RFC_4 = National Type R-154U Choke
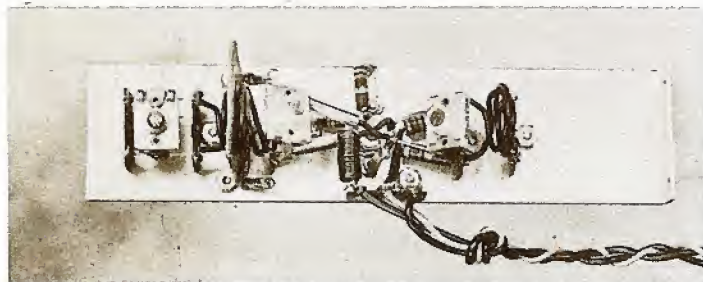
RL_1 = Keying Relay, 2.5 volt winding

* One resistor mounted across each coil for 80-, 40-, and 20-meter bands on L_5.
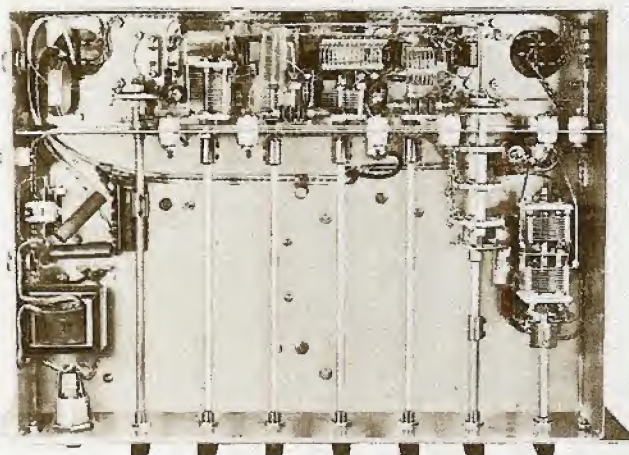
EASILY BUILT PRE-AMPLIFIER

Simplicity and low cost components do not detract from the effectiveness of the 2 meter pre-amplifier.

LOW-NOISE PRE-AMPLIFIER

(Continued from Page 1, Column 2)

because of one feature—it has only one cathode, and one cathode lead. In a push-pull class A circuit, no rf current flows through the cathode lead, and, consequently, degeneration due to cathode lead inductance is eliminated. As a result, the grids of a properly neutralized 6J6 present an input load of better than 10,000 ohms at 144 megacycles. By way of comparison, the 6AK5 rf pentode has an input resistance of approximately 3,000 ohms, a value less than one-third that of the 6J6.

The low interelectrode capacitance of the 6J6 also aids in making the amplifier broad band. A voltage gain of 8 to 10 can be obtained over the entire 144-148 megacycle band with this tube.

The tube noise of an amplifier stage containing a 6J6 should be, theoretically, about 1.5 to 2 times the thermal noise. The corresponding value for a 6AK5 is about 3 times the thermal noise. This difference may often be enough to bring some weak signals up out of the noise level so that they may be copied.

Construction Details

This low-noise broad-band pre-amplifier is built on a small sheet of metal. Six bakelite solder lug terminal strips are used. Ceramic and other low-loss mounts will not improve the performance.

The antenna coil is tuned in order to compensate for a possible serious mismatch in the feeder system and to provide a flatter response than a single-tuned circuit provides. The coil requires a tuning capacitance of about 20 to 30 uuf which can be well provided by a mica compression-type trimmer capacitor. Mica trimmers introduce small losses at low capacitance settings, their leads are short, their stray capacitances are nearly balanced to ground, and they are not expensive.

Electrostatic Shield

An electrostatic shield is used between the antenna coil and the grid coil. At first glance, this shield may seem superfluous, but when the possibility of the long feeders picking up noise or signals from powerful local stations is considered, it seems wisest to be on the safe side and include an electrostatic shield.

The shield can be made as follows: Fold a piece of plastic about 2" x 4" x 1/32" into a 2" x 2" square. Then, wind a flat coil of cotton- or silk-insulated copper wire (approximately #22 AWG) along most of the length of this flat form. Sandpaper the insulation off one side of the coil and lay a piece of heavy tinned bus wire along the edge. Solder each turn of the flat coil to the bus wire, but *be very careful not to melt or ignite the plastic.* Coat one side of the assembly liberally with household cement or coil dope. After it is thoroughly dry, cut the uncoated side away with a pair of tin snips. When completed, the shield looks like a "picket fence" of copper wires with the tips of the pickets all insulated from each other, and the bottoms all soldered to the heavy bus wire.

Grid Coil Construction

The grid coil is of the "figure-eight" variety made from solid plastic-insulated wire. This type of coil has balanced stray capacitances to ground and can be backed right up to the electrostatic shield without becoming unbalanced. Figure 2 shows the development of this winding. Some slight spreading or squeezing may be required to permit tuning the coil with the lowest possible value of grid-tuning capacitance.

The connections between the terminal strip on which the grid coil is mounted and the grid terminals of the tube socket (No. 5 and No. 6) are made with thin tubing, not wire. These tubes can be brass or copper with a bore of about 1/16 of an inch, or they can be made by rolling a strip of soft copper foil into a tubular cylinder. The socket connections are soldered so that the holes in the ends of the connecting tubes are exposed and accessible.

The grid coil is tuned by means of a 1-to-20-uuf compression-type mica capacitor. In practice, this trimmer is run almost wide open.

The neutralizing "capacitors" are short lengths of plastic-insulated #18 wire inserted about ½ inch into the grid-connecting cylinders. Some slack in the wires should be left for adjustment.

The rf plate tank is identical with the rf grid tank. No bypass capacitors or plate chokes are needed. On the assumption that the output line will be coupled tightly to a tuned circuit in the next stage, the output coil is not tuned.

Adjustment and Test

For the adjustment of this pre-amplifier, no special test equipment is needed. The procedure is as follows: Tune in a strong local signal near the middle of the band on your regular station receiver. Insert the pre-amplifier in the antenna feed line. It is well to mount the unit at a point two or three feet from the receiver, especially if the receiver is not fully shielded.

Turn on the heater voltage of the 6J6 but not the plate voltage. The signal should still be present, but weak. Then, peak up the trimmers for maximum signal. Next, with a fiber screwdriver work the neutralizing leads in and out of the tubular grid connectors. A definite signal null point should be encountered. A very great reduction in feed-through signal can be obtained when optimum neutralization is reached.

Properly neutralized, the 6J6 will not oscillate even though it is lightly loaded. From a standpoint of signal-to-noise ratio and bandwidth, however, it is best to use tight coupling in both plate and grid coils. Push the coils together and at the same time trim the tuning adjustments for greatest gain in the center of the band until the point of maximum gain is reached *and passed.* The unit should be operated with the coils over-coupled.

If everything has been done correctly thus far, the pre-amplifier is ready to operate. Turn on the plate voltage and stand by to turn down the gain controls!

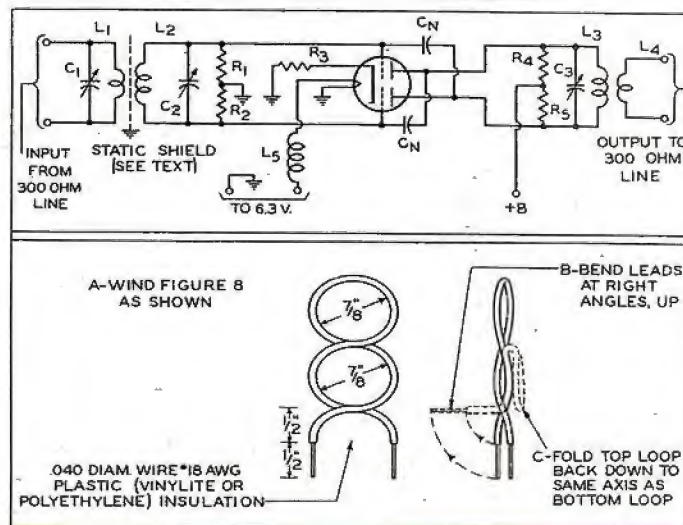| PARTS LIST	
C1	30 uuf (at mid-range) Mica-Sandwich Trimmer
C2 C3	1.5 uuf to 25 uuf Mica-Sandwich Trimmer
L1 L4	1 full turn #18 AWG plastic-insulated solid wire, ⅛" ID
L2 L3	See Figure 2, and text
L5	2-meter rf choke (20 inches, approximately, of #24 enameled wire, wound on ¼" dia. form.)
R1 R2	560,000 ohms, carbon, ¼-watt
R3	56 ohms, carbon, ½-watt
R4 R5	47,000 ohms, carbon, 1-watt

Figure 2. Schematic drawing of the pre-amplifier, and a pictorial sketch showing how the "figure-eight" grid coil is made.

VERSATILE NBFM TRANSMITTER DESIGNED FOR MOBILE USE

Hi-Fi AMPLIFIER

Featuring a low cost resistance-coupled driver stage and independent tone-control circuits for bass and treble, the amplifier delivers 10 watts of audio power with less than 2% distortion

HIGH-FIDELITY AUDIO AMPLIFIER DELIVERS 10 WATTS POWER OUTPUT

By D. P. HEACOCK
Application Engineering Group,
RCA Tube Department

Since the announcement of the RCA-6AS7-G twin power triode, many engineers and experimenters have been asking, "How can we use this tube in a high-fidelity audio amplifier?" Although an initial step in this direction was taken in a speech amplifier previously described in HAM TIPS, the amplifier described in this article goes all the way and gives a wide-range high-fidelity amplifier design capable of delivering 10 watts of audio power in the secondary of the output transformer with a distortion of less than two per cent. At a power output of ½ watt, which is a typical operating value for a home installation, there is practically no distortion (see Figure 3 for distortion characteristic of entire amplifier).

The amplifier features a low-cost resistance-coupled driver stage and independent tone-control circuits for bass and treble. It has sufficient gain to be driven by any medium-output crystal pickup such as the RCA Magic Tone Cell (RCA 211X11) which can be purchased either separately or as part of a crystal phonograph pickup arm assembly, RCA 209X1. By adding a pre-amplifier tube to the amplifier, it can also be used with any of the low-output magnetic-type pickups. A pre-amplifier with suitable compensation for this type of pickup is included in the circuit diagram, Figure 4. A stage-by-stage description of the amplifier follows.

Output Stage

The output stage uses the 6AS7-G operating in a class A push-pull circuit. Two separate cathode-bias resistors are used for bias on the two triode sections. The regulation produced by these two resistors makes it generally unnecessary to provide any special balancing circuit to equalize the current in the two triode units. The plate-supply voltage is 375 volts and the plate current per triode unit is 50 ma. Thus, the developed bias is 125 volts and the effective plate voltage is 250 volts. Each cathode is bypassed with an electrolytic capacitor to eliminate degeneration. Since the 6AS7-G is

(Continued on Page 3, Column 2)

10-METER RIG WITH 2E26 FINAL OPERATES ON BOTH PHONE AND CW

By H. W. BROWN, JR., W2OQN, ex-W1KIQ
Aviation Transmitter Section
RCA Victor Division

Here is a little rig, a complete 28-Mc transmitter, which can afford the operator much pleasure in either a mobile or fixed station location. This rig will especially hit the spot for those who travel by automobile and are away from home a lot. It is small, light, and versatile enough so that it can be carried about and set up at any location with not much more effort than hooking on the antenna and plugging into an appropriate power source. The transmitter features push-to-talk nbfm, or cw operation in either the 10- or 11-meter band. The power supply may be operated from either 6 V dc or 110 V ac.
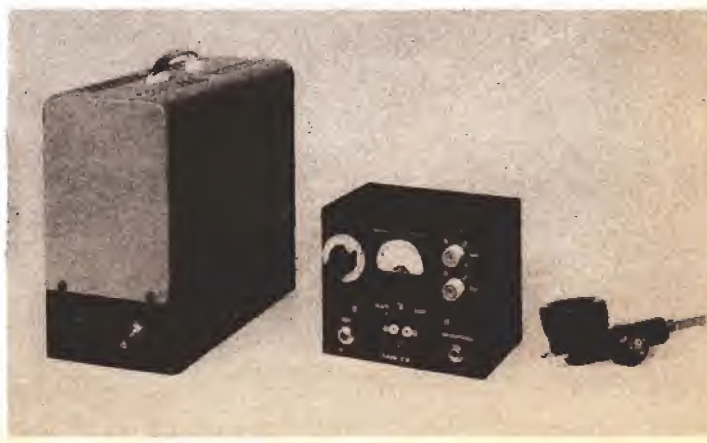
Crystal Reactance FM

The basic device used for obtaining frequency modulation is something new and is known as the Gerber Crystal Reactance System. Its principle of operation briefly is as follows. An inductor, which is tuned slightly higher than the crystal frequency, is inserted in series with the crystal. The total inductance in the oscillator grid circuit is, therefore, increased. In order to meet the conditions for oscillation, the crystal will then assume a lower value of equivalent inductance and a lowering of the crystal operating frequency will result. In Figure 1, a typical reactance curve for a crystal, f_1 and f_2 designate points of series and parallel resonance, respectively.

Point f_n is an operating point which meets the necessary conditions for operation. When an inductive reactance is added to the circuit, the crystal is required to adjust itself to a new frequency marked f_b for the total reactance to remain constant. If the magnitude of the added inductance is then varied electronically, as with a reactance-tube modulator, the crystal frequency will then swing up and down along the crystal reactance characteristic. Extremely wide deviations are possible with this system; deviations in the neighborhood of 20 kc are not uncommon at even 3 Mc. In this particular application, however, no such deviation is necessary.

(Continued on Page 2, Column 1)

READY FOR ACTION!

This efficient looking rig features the new crystal reactance system for obtaining frequency modulation. It's a natural for Amateurs who do a lot of travelling by automobile.
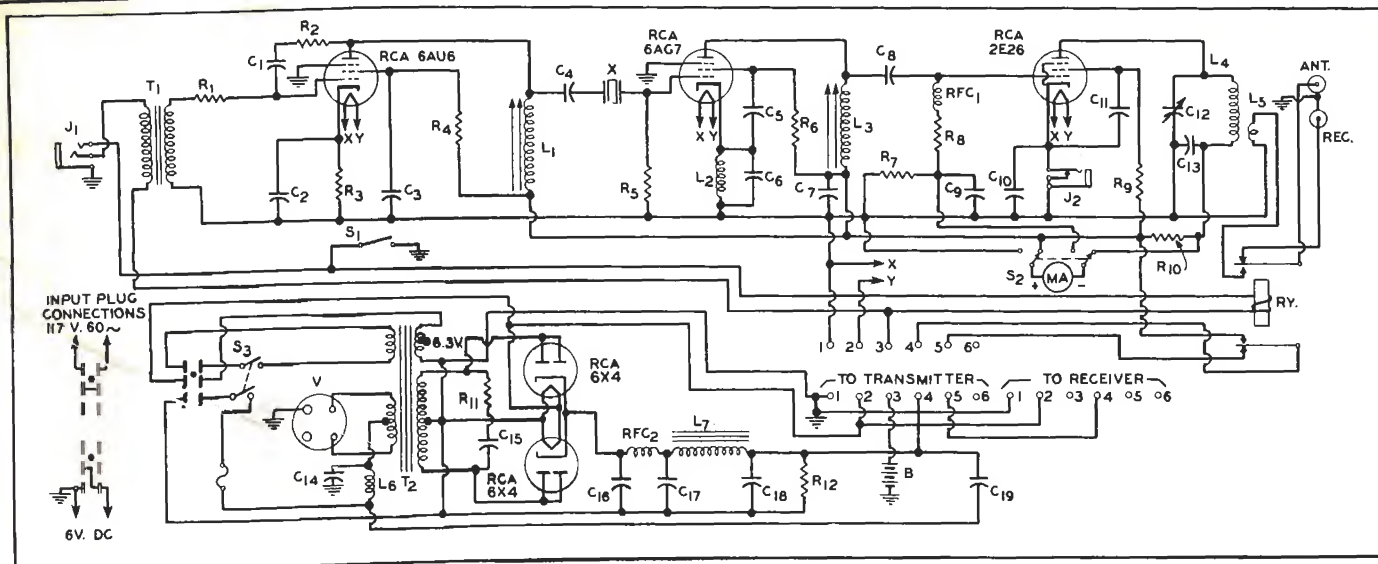
Figure 2. Schematic diagram of the 10-meter transmitter.

MOBILE RIG

(Continued from Page 1, Column 4)

RF Section

The crystal oscillator operates with a 7-Mc crystal and L_1 is the series inductor which produces the frequency deviation. The 6AG7, an excellent tube for oscillator-multiplier service because of its high control-grid screen-grid Mu factor, quadruples to 28 Mc. The
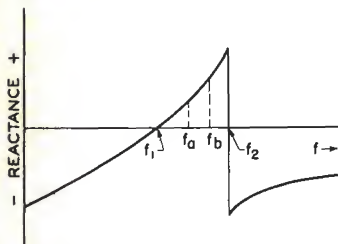

Figure 1. Typical reactance curve for a crystal.

output of the 6AG7 drives a 2E26 final of conventional design to about 10 watts using the described power supply. The oscillator is basically a standard "Hot-Cathode Colpitts" circuit with a few modifications. Because it is desirable in this application to have good harmonic output consistent with low crystal current, the screen of the 6AG7 is bypassed to the cathode, and instead of a conventional 2.5-mh choke in the cathode tank circuit, an Ohmite Z-1 choke (L_2) is used. This choke resonates closer to the crystal frequency, increasing the harmonic output considerably. Because the series inductor and the reactance tube introduce some losses into the oscillator, these two special design features are necessary so that ample drive is available for the final.

The reactance-tube modulator is conventional and uses a 6AU6 miniature pentode, which operates very satisfactorily. Adequate drive to obtain sufficient deviation is available directly from the microphone transformer.

The table below gives voltage and current measurements for the rf section.

	6AU6	6AG7	2E26
Plate volts	290	290	290
Plate milliamperes	3	30	60
Input watts	0.87	8.7	17.4
Screen volts	150	240	180
Screen milliamperes	2	6	10
Control-grid milliamperes	—	—	2.2
Power-output watts	—	--	10

A T-17B surplus Army single-button carbon microphone was used with this rig, the push switch on the mike performing the dual function of energizing the send-receive relay which switches the antenna and B+ from the receiver to the transmitter and controlling the mike current. Because the transmitter was designed to work from either a dc or ac input, it was necessary to include a microphone battery. If only dc operation is contemplated the relay and mike voltage may be obtained from the main storage battery.

It may be observed that there is no front panel control for the oscillator tuning. It was found that if the slug on L_6 is set for middle-of-the-band operation, there is no appreciable difference in power output when crystals of other frequencies are used. It proved necessary, however in the interest of efficient operation to provide a tank tuning control on the 2E26 final amplifier.

L_1 should be adjusted to the point where a frequency shift of about 5 kc is observed between the conditions when it is shorted out and when it is in the circuit. It is comparatively simple to adjust the deviation merely by listening to the modulation frequency in a receiver and setting L_1 accordingly; however, it is desirable to check the actual deviation by any of the usual methods.

It may also be noted that provision (J_2) has been made for keying the 2E26 cathode circuit. So that one would not have to keep

BACK STAGE SCENE

An underchassis view of the transmitter reveals simplicity of construction and the compact manner in which wiring and components are arranged.

the mike button depressed to hold in the relay, a separate phone-cw switch, S_1, has been provided. This switch closes the circuit to the relay.

Metering is accomplished by switching a meter (0-10 ma) from the grid to the plate of the 2E26. When plate current is measured, a shunt is automatically connected into the circuit which multiplies the meter readings by 10. The exact value of this shunt (R_{10}) may be calculated or it may be determined by cut-and-try methods.
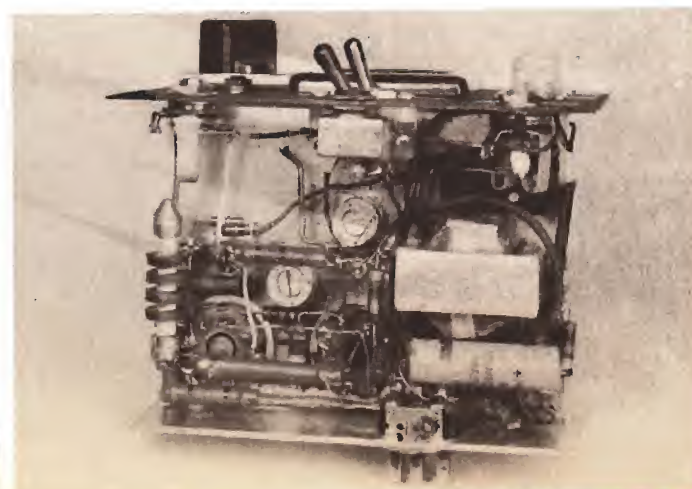
Construction and Layout Details

The entire rf section is built into a 4" x 5" x 6" standard cabinet. The chassis layout is illustrated in the photo on bottom of page 3. From left to right may be seen the relay and the 6AU6, the 6AG7, and the 2E26 with its tank circuit. The deviation control L_1 is under the meter while the oscillator-tank tuning slug is between the 6AG7 and the 2E26. The rf output is brought out to standard co-ax connectors on the front panel.

Power Supply

As mentioned above, the power supply is designed to work from either a 6-volt battery or 110-volts ac. To accomplish this a Thordarson transformer (type T-22R24) with a dual input is used in conjunction with a vibrator. For battery operation, of course, it is desirable to run the filaments from the dc source, so a switching arrangement is included with the power input plugs. A heavy-duty male 6-connector Jones plug on the chassis is used for input and two matching female receptacles are used on the power cables. Connecting the appropriate plug to the unit automatically makes the proper filament connections. Two miniature 6-connector female chassis-mounting-type Jones receptacles are used for output power and con-

MOBILE RIG

trol circuits: one feeds the transmitter and one the associated receiver. A pair of 6X4 rectifier tubes, connected in parallel, will furnish more than enough current to operate the transmitter. Approximately 300 volts is available from the supply.

PARTS LIST

R_1, R_2, R_4 = 68,000 ohms
R_3 = 680 ohms
R_5 = 47,000 ohms
R_6 = 8,200 ohms, 1 watt
R_7 = 47 ohms
R_8 = 10,000 ohms
R_9 = 10,000 ohms, 5 watts
R_{10} = Meter Shunt
R_{11} = 5,000 ohms, 1 watt
R_{12} = 220,000 ohms
C_1, C_6, C_8 = 100 $\mu\mu$f, 600 W.V. (Hi-Kap)
C_2 = 10 μf, 25 W. V.
C_3 = 1μf, 400 W. V.
C_4 = 1,500 $\mu\mu$f
C_5, C_7, C_9, C_{10}, C_{11}, C_{13} = CRL Hi-Kaps, 5,000 $\mu\mu$f, 600 W. V.
C_{12} = 15$\mu\mu$f, Variable, Johnson 160-107
C_{14} = 5μf, 200 W. V.
C_{15} = .01 μf, 1,600 W. V.
C_{16} = .01 μf, 600 W. V.
C_{17} = 8 μf, 450 W. V.
C_{18} = 30 μf, 450 W. V.
C_{19} = 100 $\mu\mu$f, mica
V = Vibrator, Mallory 825C
Ry = Relay dpdt, 6 volt dc
F = Fuse, 25 amp
RFC$_1$, RFC$_2$ = 2.5 mh
B = 6 V. Battery, RCA-VS009
T_1 = Microphone transformer, Stancor A-4706
T_2 = Dual Power transformer, 6 volts & 110 volts input, Thordarson T-22R24
J_1 = 3 conductor microphone jack
J_2 = Key jack, closed circuit
S_1 = SPST toggle switch
S_2 = DPDT toggle switch
S_3 = DPST toggle switch, 15 amp.
Ma = 0-10 ma DC meter 3″
L_1 = 37 turns, #30 enamelled, 2 layers on Millen Form #69041
L_2 = Ohmite Z-1 choke
L_3 = 10 turns, #24 enamelled on Millen Form #69041
L_4 = 10 turns, #16, ¾″ diameter, ¼″ long (air wound)
L_5 = Antenna link—3 turns, #16 over cold end of L4
L_6 = Hash choke, Mallory—RF583
L_7 = Filter choke—Stancor C-1421
X = Appropriate 7 Mc crystal
NOTE: All resistors ½ watt unless otherwise noted.


AUDIO AMPLIFIER

a cathode type tube, the heater supply (6.3 volts, 2.5 amperes) is obtained from the same transformer winding used for the other tubes in the amplifier.

Throughout the amplifier, resistance-coupled triode amplifier stages are used. Consequently, the circuit component mainly responsible for determining the frequency response of the amplifier is the output transformer. Use of a low-price, low-quality output transformer is simply not good economy in a high-quality audio system. After some experimentation with transformers in various price ranges, a UTC CG-16 transformer was selected as one of the reasonably priced transformers with good characteristics.

Driver Stage

It has been generally believed that adequate voltage for driving the 6AS7-G could be obtained only by the use of a transformer-coupled driver stage. This type of circuit is used in the speech amplifier mentioned previously. For such an application, transformer coupling is excellent because it provides the frequency cutting so desirable in a unit designed to handle voice-frequency components only. It is an expensive proposition, however, to use a truly high-fidelity audio interstage transformer in a high-fidelity wide-range amplifier. Considerable work was done, therefore, to devise a way to drive the 6AS7-G with a resistance-coupled push-pull driver. The circuit which was finally evolved uses a 6SN7-GT with a plate supply of 375 volts. Because of the voltage drop in the plate load resistors, operation is well within tube ratings. Degeneration, introduced into the circuit by the use of unbypassed cathode resistors, tends to reduce distortion in the output signal to a very small value. The grid resistors of the triodes in

WIRING DETAILS OF THE AMPLIFIER
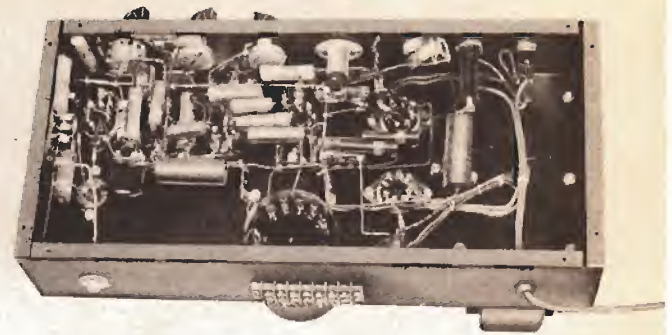
A bottom view of the amplifier showing how components are located to obtain maximum fidelity and minimum distortion and hum.

the driver stage are returned to the junction of the series cathode resistors to provide the correct bias.

Excitation for the driver stage is obtained from the familiar split-load phase inverter. This method was used in preference to the more common one of obtaining the grid signal voltage for one driver tube by tapping off the load of the other driver stage. The reasons for this choice are: first, the over-all distortion is slightly less because the grids of both driver units are provided with an undistorted signal. Further, the circuit employed is inherently balanced and requires no careful balancing after completion in order to determine the proper point for tapping off the signal for the second driver unit.

Tone Control Stages

Preceding the phase inverter are three additional triode amplifier stages. In order, working back from the phase inverter, these stages are the treble tone-control stage, a voltage amplifier stage, and the bass tone-control stage. In the design of tone control stages several features are desirable. Separate controls should be provided for both bass and treble frequencies; there should be no interaction between the controls; and frequency boost

and frequency attenuation should be obtained from the same control without switching. Further, it was considered desirable to avoid the use of any inductors not only because of cost, but also because of possible hum pickup problems.

Interaction between the bass and treble tone controls is eliminated by putting each in a separate stage. The treble tone-control stage is a resistance-coupled amplifier stage with a large unbypassed cathode resistor. A potentiometer (R_{23}) in series with a 0.005-μf capacitor (C_{17}) is connected between the plate of the tube and the junction of the two cathode resistors. From the arm of the potentiometer a capacitor is connected to ground. When the arm of the potentiometer is at the plate end, the plate load resistor is shunted by the 0.005-μf capacitor (C_{17}) and the 0.02-μf capacitor (C_{18}) in series, and the high frequencies are attenuated. When the arm of the potentiometer is at the cathode end, the cathode resistor is bypassed by the 0.02-μf capacitor. This bypass is effective only at the higher audio frequencies and reduces the degeneration in the stage thereby increasing the gain and giving treble boost.

UP AND OVER
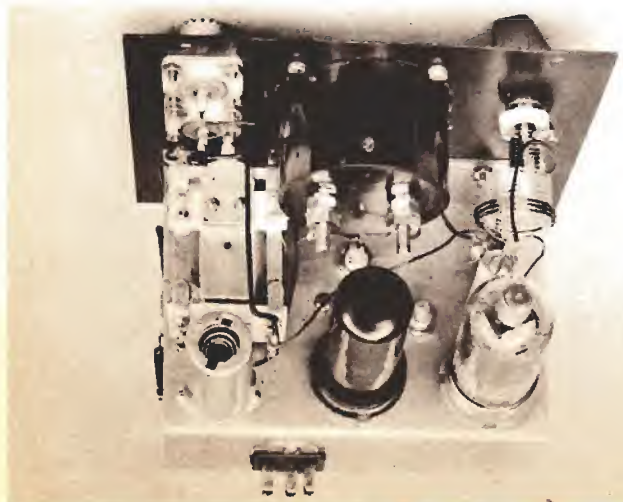
Tubes and relay are mounted with room to spare on small 4″ x 5″ x 6″ chassis. The 2E26 tube and tank circuit are shown on the upper right portion of the photo.
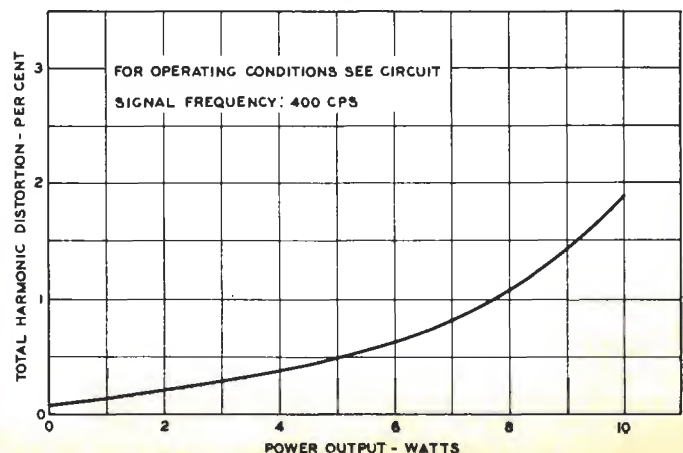

FOR OPERATING CONDITIONS SEE CIRCUIT
SIGNAL FREQUENCY: 400 CPS

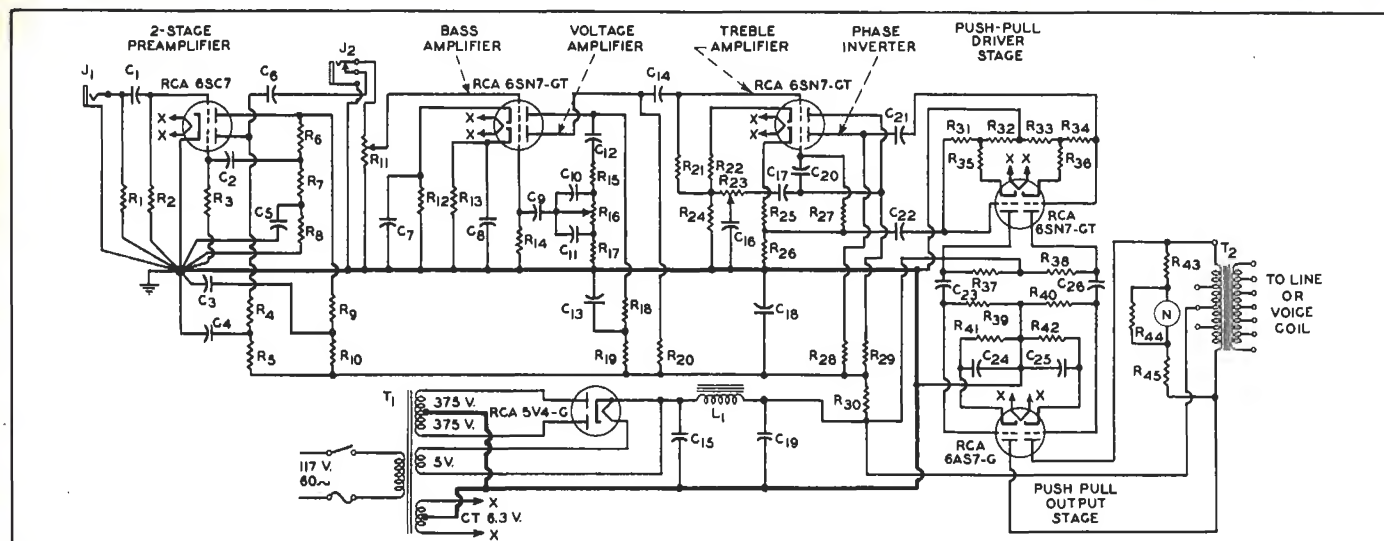*Figure 3. Total distortion versus power output.*

Figure 4. Schematic of the high fidelity amplifier.

AUDIO AMPLIFIER

(Continued from Page 3, Column 4)

The bass tone-control network is inserted between the two units of the first 6SN7-GT. It is located in an early stage to avoid boosting any hum voltages produced in any of the later amplifier stages. When the arm of the potentiometer is all the way down, the 0.03-μf capacitor (C_{11}) is shorted out, and bass attenuation is provided by the 0.01-μf capacitor (C_{10}) which limits the transmission of the low frequencies. When the arm of the potentiometer is at the plate end, the 0.01-μf capacitor is shorted out, and the 0.03-μf capacitor serves to increase at low frequencies the output of the voltage divider made up of the 100,000-ohm resistor, (R_{15}), the 0.03-μf capacitor (C_{11}), and the 10,000-ohm resistor (R_{17}). This arrangement provides bass boost.

The circuit constants are so chosen that the tone controls have negligible effect on the output at about 800 cycles. At 60 cycles a boost of 13 db or an attenuation of 12 db is possible. At 6000 cycles a boost of about 10 db or an attenuation of about 11 db is possible. Flat response is provided by intermediate adjustment of the controls. The over-all response of the amplifier for maximum and minimum adjustment of the bass and treble controls is shown in the curves of Figure 5.

Phonograph Pickup

The amplifier can be driven to full output with a signal of about 0.6 volt RMS at the volume control. The RCA 211X1 Magic Tone Cell crystal pickup has an output of about 1.5 volts and is excellent for use with this amplifier. This pickup gives high-quality reproduction and does not ordinarily require compensation.

If it is desired to use one of the low-output magnetic-type pickups, a pre-amplifier is required. The pre-amplifier circuit shown in the schematic, Figure 4, will provide the necessary gain and proper equalization for this type of pickup. A rubber shock-mounted tube socket should be used for the 6SC7 to minimize microphonic disturbances.

Hum

In order to obtain satisfactory performance from any high-fidelity amplifier, precautions must be taken to keep hum to an absolute minimum. In this amplifier, hum is kept down by observing the following precautions which serve to prevent minute voltage drops caused by high currents in the power supply or high-level stages from flowing through a ground circuit which is common to that used in the low level stages. Ground returns are made through a bus and not through the chassis. The electrolytic capacitors in the power supply are not grounded to the chassis but are mounted on insulating washers. The B- or ground bus is run from the center tap of the power transformer to the negative side of the electrolytics and then to the power output stage, the driver stage, and back through the early stages of the unit, picking up the ground returns in succession. The ground bus is finally tied to the chassis near the input jack. The hum output of the amplifier as constructed does not exceed 10 microwatts at the full output level.

PARTS LIST

C_1, C_3 = .05 μf
C_3, C_4 = 20 μf, electrolytic, 450 W.V.
C_5, C_9, C_{10} = 0.01 μf
C_6, C_{16}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24} = 0.02 μf
C_7, C_8 = 25 μf, electrolytic, 50 W.V.
C_{11} = 0.03 μf
C_{12} = 0.01 μf
C_{13} = 8 μf, electrolytic, 450 W.V.

C_{14}, C_{17} = 0.005 μf
C_{15}, C_{19} = 15 μf, electrolytic, 450 W.V.
C_{18} = 10 μf, electrolytic, 450 W.V.
C_{24}, C_{25} = 20 μf, electrolytic, 150 W.V.
T_1 = 375-0-375, 160 ma., Thordarson —T22R33
T_2 = Output transformer, UTC-CG-16, plate to plate load 5000 ohms
L_1 = 12 h, 150 ma., Thordarson T17C00-B
J_1 = Phone jack
J_2 = Closed circuit—phone jack
N = $\frac{1}{4}$ watt neon lamp
R_1 = 5,600 ohms
R_2, R_3 = 3.3 Megohms
R_4, R_5, R_{29} = 33,000 ohms
R_6 = 200,000 ohms
R_7 = 27,000 ohms
R_8 = 180,000 ohms
R_9, R_{10} = 68,000 ohms
R_{11} = 0.5 Megohm, Potentiometer
R_{12}, R_{13}, R_{22} = 1,500 ohms
R_{14}, R_{21}, R_{27}, R_{31}, R_{34}, R_{39}, R_{40} = 0.5 Megohm
R_{15}, R_{43}, R_{45} = 100,000 ohms
R_{16} = 1 Megohm Potentiometer
R_{17}, R_{24} = 10,000 ohms
R_{18}, R_{20}, R_{26}, R_{28}, R_{37}, R_{38} = 47,000 ohms
R_{19} = 20,000 ohms
R_{23} = 0.25 Megohm, Potentiometer
R_{25} = 4,700 ohms
R_{30} = 10,000 ohms, 2 watts
R_{32}, R_{33}, R_{35}, R_{36} = 2,700 ohms
R_{41}, R_{42} = 2,500 ohms, 10 watts—wire wound
R_{44} = 75,000 ohms
All capacitors are 600 volts paper unless otherwise specified.
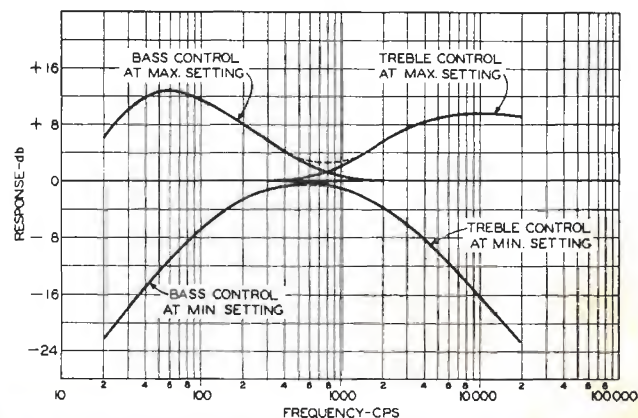All resistors are $\frac{1}{2}$ watt unless otherwise specified.
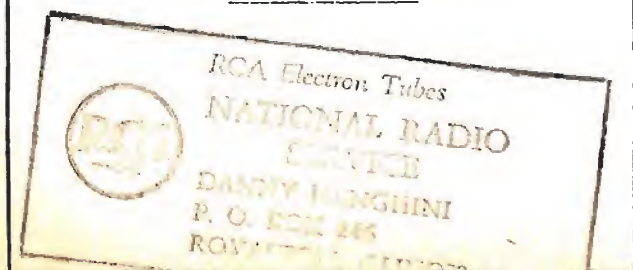
Figure 5. Over-all response of the amplifier for maximum and minimum adjustment of bass and treble controls.

NEW PRACTICAL METHOD DEVELOPED FOR CURING TVI!

Holiday Greetings...
our sincere wishes for you...
good health, much happiness
and abundant dx

SIMPLIFYING THE CALCULATION OF TRANSMITTING TRIODE PERFORMANCE

By E. E. SPITZER
Power Tube Group
RCA Engineering Section

Simple methods of calculating transmitting triode performance are presented in this article which give results very close to published data. They are applicable to class C amplifiers both modulated and unmodulated and also to class B audio amplifiers.

Published data on transmitting tubes show many typical operating conditions which are excellent guides for the operation of the tubes. Conditions sometimes arise, however, which make other operating conditions desirable or necessary.

Many amateurs would probably like to calculate new tube operating conditions but are deterred by the apparently formidable mathematics involved. In this article, the mathematics for the calculations of class C amplifiers are very much boiled down by eliminating one variable, the length of the plate-current pulse. For our calculations, this variable is assumed to be 140 degrees of an rf cycle. 140 degrees is a representative value for class C amplifiers. With this assumption, five simple formulas permit calculation of power output, plate loss, grid bias, grid current, and driving power.[1] The same method of calculation is extended to class B audio amplifiers by using a plate pulse of 180°. Several examples are worked out to show clearly how the methods are used.

In the method described here, the calculations are based on the in-stantaneous values of grid and plate current at the peak of the plate-current pulse. It is well known that this peak occurs when the grid voltage is at its peak positive excursion and the plate voltage is at its peak negative excursion. When these two voltages are equal, the tube has very nearly its optimum performance. This important fact is recognized in the tube characteristic curves by the inclusion of a curve labeled $E_c = E_b$. The 812-A characteristic curves shown in Figure 5 include this limiting curve. If we choose a point such as "A" on the $E_b = E_c$ curve in Figure 5, we can read directly the instantaneous plate current, the required plate and grid voltages, and then, by dropping down to point "B" on the I_c family, we can also read the in-stantaneous grid current for the same grid voltage. All calculations are then made using these values.

Class C Operation
(Telegraphy and Telephony)

It is assumed that we have data on the tube including the plate-characteristics curves. It is also assumed that we want to operate at a certain value of dc plate voltage,

REDUCING THE HARMONIC POWER OUTPUT OF AMATEUR TRANSMITTERS

By JOHN L. REINARTZ, W3RB
RCA Tube Department

Although it is not generally realized, most amateur transmitters using but one tuned circuit in the final output stage cannot meet the FCC rule stated in Article 17, Act of 1947 with regard to the reduction of the radiation of harmonic frequencies to not less than 40 db below the output of the fundamental frequency.

This article is the first of a series on harmonic reduction which will present some practical methods of minimizing TVI at the source.

Why We Have Harmonics

All tubes generate harmonic components when operated under class C conditions. Each time the grid of the tube is driven positive, a current pulse flows in the plate circuit of the tube. The current value for each of the harmonics produced depends on the angle of plate-current flow. For example, for a plate-current-flow angle of 140° the harmonic relationships[1] are given in Table I.

TABLE I

Component	Current, % of Fundamental	Equivalent Power level referred to Fundamental (db)
Fundamental	100	0
Second Harmonic	69.4	— 3.2
Third Harmonic	30.8	—10.3
Fourth Harmonic	4.6	—25.8

The voltages produced across the output circuit by these harmonic components are dependent on the magnitude of the impedances presented to each harmonic component by the tuned circuit and are dependent to a large degree on the Q of the tuned circuit.

The performance of any amplifier in a transmitter is determined by both the characteristics of the associated tuned circuit and the tube. The choice of the tube has been made easy for us by the manufacturer who has supplied us with the necessary tube characteristics and operating values. It is, therefore, only necessary to consider the rf circuit constants that should be used. C, L, and R can be of various values within rather large limits, and, if frequency were the only consideration, the capacitance could be made small and the inductance large or vice versa. The action of the reflected load resistance on the tuned tank circuit is to decrease the sharpness of tuning as its shunt value is made smaller. In actual practice, however, there is a compromise value for the three components which results in high efficiency and good harmonic suppression.
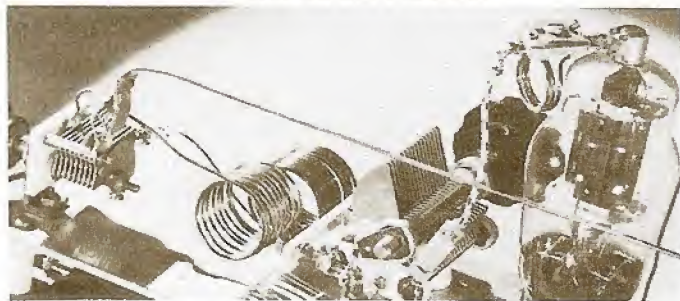
Now, the larger the value of the tuning capacitor, the smaller the

EXPERIMENTAL MODEL

This one-stage rig was designed to reduce harmonic radiation and resultant television interference. Although it is not the unit described in HAM TIPS, it utilizes the same practical method discussed.

WHAT THE DOCTOR ORDERED

Component details which were found essential for reducing harmonic output are shown in this close-up. A plate shunt trap in upper right of photo reduces harmonic pulses generated at the plate of the 807. An absorption trap coil, center, tunes to the harmonic and changes the phase relation with respect to the plate tank tuning system. Cancellation of stray harmonic currents traversing the chassis is accomplished by means of a cancellation wire shown running parallel with chassis.

HARMONIC POWER OUTPUT

(Continued from Page 1, Column 4)

impedance it presents to the harmonic components in the plate-current pulse. Consequently, the harmonic voltage produced across this capacitor is smaller. In addition, there is a larger circulating current in a larger capacitance for a given power output. It is this ratio, called Q, of the circulating volt-amperes, (rf voltage times circulating current) to the power output, that determines the harmonic
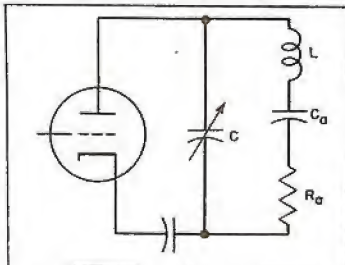

Figure 1. A single-tuned circuit.

put, that determines the harmonic power that can be passed on. The harmonic power is higher for low Q and lower for high-Q circuits.

Harmonics are suppressed to a considerable extent even by a simple tuned circuit.[2] For example, if the tuned tank circuit is as shown in Figure 1 where R_a and C_a are the antenna resistance and capacitance, then the db reduction of harmonics in the antenna due to the Q of the tank circuit is given in Table II.

TABLE II
HARMONIC REDUCTION in db DUE TO A SINGLE-TUNED CIRCUIT REFERRED TO FUNDAMENTAL-FREQUENCY POWER

Q	Second Harmonic	Third Harmonic	Fourth Harmonic
5	—23.5	—32.0	—37.5
10	—29.6	—38.1	—43.5
15	—33.0	—41.6	—47.0
20	—35.6	—44.1	—49.6

adding these values to those given in Table I gives—

TABLE III
HARMONIC POWER OUTPUT in db OF TUBE AND SINGLE-TUNED CIRCUIT REFERRED TO FUNDAMENTAL-FREQUENCY POWER

Q	Second Harmonic	Third Harmonic	Fourth Harmonic
5	—26.7	—42.3	—63.3
10	—32.8	—48.4	—69.3
15	—36.2	—51.9	—72.8
20	—38.8	—54.4	—75.4

We see from these tabulations that every time we double the Q of the tuned circuit the harmonic level goes down by 6 db. For the second harmonic, however, this reduction is still insufficient to comply with the FCC rule of —40 db even when the Q of the tuned circuit is 20.

Harmonic Suppression in Double-tuned Circuit

If the circuit is doubly tuned as in Figure 2, there is an even greater reduction in harmonics as shown in Table IV.

TABLE IV
HARMONIC REDUCTION in db DUE TO 2 COUPLED CIRCUITS REFERRED TO FUNDAMENTAL-FREQUENCY POWER

Q	Second Harmonic	Third Harmonic	Fourth Harmonic
5	—38.2	—54.4	— 76.8
10	—50.2	—67.4	— 88.8
15	—57.3	—75.1	— 96.2
20	—62.3	—79.4	—100.8

It can be seen from this tabulation that whenever the value of Q is doubled the harmonics are all reduced by 12 db. Another important fact that can be deduced from these tables is that it is better to have a Q of say 10 in each tuned circuit of Figure 2 than to have a Q of 20 in the single tuned circuit of Figure 1. Now we can meet the FCC rule of —40 db for harmonic radiation if we use a Q of 10 or better in each of the tuned circuits. This —40-db value represents 0.01 watt for an amateur station radiating 100 watts at the fundamental frequency.

Field-Strength Considerations

Let us consider the field strength produced by an antenna. The field strength produced by a horizontal half-wave dipole[6] is

$$E = 23 \frac{\sqrt{P}}{d} \text{ volts per meter,}$$

where P is the radiated power in watts and d is the distance in feet from the radiator to the point where E is measured. This value can be considered an average value. Actually, the field strength varies with distance between a lower and higher value because of subtraction and addition of the wave reflected from the ground and the direct wave, and also because the configuration of the lobes changes with the effective length of the transmitting antenna for any particular har-

monic. The formula is useful for distances up to about 650 feet. Since the amateur is concerned with distances within this value down to say 50 feet, the above formula for field strength applies. Inversion of the formula will give the power required to produce a given field strength.

$$P = 1880 \ (Ed)^2 \text{ microwatts,}$$

where E is in volts/meter and d is in feet.

The limiting field strength for the service area of a television transmitter is considered by the FCC to be 500 microvolts per meter in residential and rural areas. It has been determined that an interfering
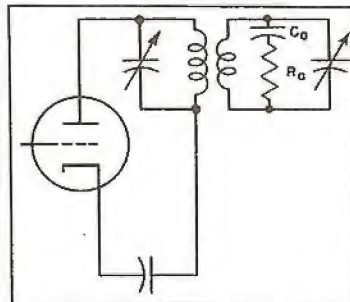

Figure 2. A double-tuned circuit.

signal of 1/100 this value is not objectionable. The amateur, therefore, should not produce an interfering field greater than 5 microvolts/meter for such a service area.

Let us now find the power required to produce such a field at 500 feet.

$$P = 1880 \ (5 \times 10^{-6} \times 500)^2 = 0.012 \text{ microwatts.}$$

Compare this 0.012-microwatt value with the 0.01 watt (10000 microwatts) which the present FCC rulings allow for harmonic radiation when the radiated fundamental output is 100 watts. A 0.01- microwatt value represents a power ratio of harmonic to fundamental values of 10^{-9} or —100 db when the power radiated at the fundamental is 100 watts. This changes to 10^{-11} or

—110 db when the fundamental power is 1000 watts. These values are far more severe than the —40 db level currently required, but are what the amateur must attain if he wants to stay on good terms with the general public.

Other Methods of Reducing TVI

Because even two tuned tank circuits may fail to reduce an interfering signal to the —100 or —110 db level, other means must be found. Several good articles on the subject have appeared in amateur magazines. Mack Seybold has shown in the August 1947 issue of QST that the addition of trap circuits in the plate lead of the final class C stage will reduce the harmonic level some 40 to 50 db and if considered along with two tuned tank circuits may reach the desired —100 or —110 db level.

Harmonic Suppression

In cases where even the processes outlined above fail to reduce the interference to television reception at distances shorter than 500 feet, it will be found advantageous to resort to additional grounded trap circuits tuned to the interfering harmonic. These trap circuits should be closely coupled to the hot end of each plate tank circuit of every stage in the transmitter. Such a system, devised by the writer, was found capable of apparently completely cancelling a harmonic. Because every rf stage in a transmitter amplifies the harmonic components present in its grid ex-

IN DOUBLER SERVICE EMISSION COUNTS

It takes a lot of cathode emission to back up heavy peak plate current pulses when driving a frequency-multiplier tube for optimum gain. That's why RCA high-transconductance beam power tubes are preferred types for medium-power doubler and tripler service. They produce maximum plate-current swing for a given grid signal voltage. And they have the high-power filaments and heater-cathodes required to handle high peak plate-current . . . with emission to spare.

SIMPLIFIED CALCULATIONS

(Continued from Page 1, Column 2)

E_b, and with a certain average plate current, I_b. We want to know power output, P_o, grid bias, E_c, dc grid current, I_c, and driving power, P_d.

First we find the peak plate current. This value is 4 times the average plate current, I_b. Then, we go to the plate-characteristics curves and on the curve $E_c = E_b$, we find the instantaneous plate voltage e_b, and the instantaneous grid voltage e_c, at which we get the plate current of 4 I_b. With these values, together with the amplification factor, μ, obtained from the tube data, we then apply the following formulas.

Power output

$$P_o = 0.86 \ (E_b - e_b) \ I_b \ \text{(watts)} \quad (1)$$

Plate loss

$$P_p = E_b \ I_b - P_o \ \text{(watts)} \quad (2)$$

Grid bias

$$E_c = \left[\frac{E_b}{\mu} + 0.52 \ \frac{(\mu + 1)}{(\mu)} \ e_b \right] \text{(volts)} \quad (3)$$

Peak rf driving voltage

$$e_g = E_c + e_c \ \text{(volts)} \quad (4)$$

To get the dc grid current, I_c, we first have to calculate $\frac{E_c}{e_g}$ the ratio of the grid bias to the peak rf driving voltage and then from Figure 4 get $\frac{I_c}{i_c}$ the ratio of average grid current to the instantaneous grid current at $E_c = E_b$. The instantaneous grid current is obtained from the characteristic curves.

Then, the average grid current,

$$I_c = i_c \times \ \left(\text{ratio } \frac{I_c}{i_c} \text{ from}\right.$$

Figure 4), (amperes)   (5)

and driving power

$$P_d = 0.9 \times e_g \times I_c \ \text{(watts)} \quad (6)$$

The calculated power output figure as well as the published typical power output values are theoretical values of tube output that include both useful output and rf losses in the tube, in the tank circuit, and associated wiring. Useful rf power obtainable, therefore, will depend on the efficiency of the circuit and in turn upon the quality of components and circuit layout used.

The calculated value of driving power includes only the actual power input to the grid plus the power lost in the bias supply. It
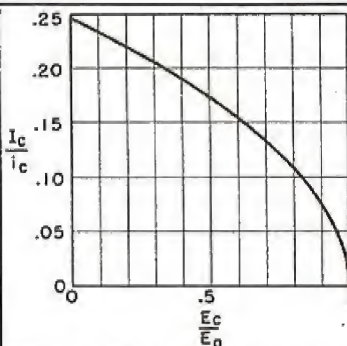
Figure 4. Curve from which ratio of $\frac{I_c}{i_c}$ is obtained.

does not include rf losses that occur in the driver-stage tank circuit, in coupling from the driver stage, in the socket and wiring or losses in tubes caused by transit-time loading. The driver stage power output, therefore, should be substantially greater than the calculated value of driving power in order to provide an adequate range of adjustment for optimum transmitter performance.

Example

As a check, this method may be applied to the 1500-volt ICAS Telegraphy condition given in the published data for the 812-A (Figure 6 on page 4). The given conditions are $E_b = 1500$ volts, $I_b = 173$ Ma., $\mu = 29$. The peak plate current is $4 \times 173 = 692$ ma. This value of current can be obtained at $e_c = e_b = 120$ volts, as given in the plate characteristics, Figure 5, at point A.

Power output

$$P_o = 0.86 \ (1500 - 120) \ 0.173$$
$$= 205 \text{ watts}$$

Plate loss $P_p = 1500 \times 0.173 - 205$
$$= 259 - 205 = 54 \text{ watts}$$

Grid bias

$$E_c = - \left[\frac{1500}{29} + 0.52 \ \frac{(30)}{(29)} \ 120 \right]$$
$$= -116 \text{ volts}$$

Peak rf driving voltage
$$e_g = 116 + 120 = 236 \text{ volts}$$
$$\text{and} \frac{E_c}{e_g} = \frac{116}{236} = 0.49$$

From Figure 4, $\frac{I_c}{i_c} = 0.175$

From the characteristic curves (Figure 5) for $e_c = e_b = 120$ volts, $i_c = 220$ ma. or 0.220 amp. at point "B".

FOUNTAINHEAD OF TUBE INFORMATION

Amateurs everywhere look to RCA tube publications for accurate data and unquestioned authoritativeness. For information on the material shown, see your local RCA Distributor, or write Commercial Engineering, RCA, Harrison, N. J.

HARMONIC POWER OUTPUT

(Continued from Page 2, Column 4)

citation voltage, the first place to get rid of the harmonic is at the crystal oscillator plate-tank circuit. What may be left can be taken care of in subsequent stages at their respective plate tank circuits.

To prove the effectiveness of this system, a 2E26 oscillator-doubler, controlled by a 7-Mc crystal, followed by an 813 final was built having the shunt traps roughly tuned to 28 Mc and the grounded traps (tuned to the offending harmonic, approx. 28 Mc) coupled closely to each plate tank circuit.

In some cases, it may be necessary to tune one or more of these traps to the third harmonic, to obtain greater reduction of interference.

The essentials of this circuit are shown in Figure 3. A television receiver was set up ten feet away and connected to a standard 90″ folded - dipole antenna through 100″ of 300-ohm, twin-lead transmission line. The antenna for the transmitter was strung within 8 feet of the TVR antenna. With normal excitation to the 813 tube in the 20-meter band and with the TVR tuned to channel 2, it was possible to operate the transmitter with 100% 60-cycle modulation without undue interference to the TVR even though the transmitter was incompletely shielded in that the entire top cover of the transmitter cabinet was removed. The measured output from the 813 was adjusted to 150

watts as a convenient value for testing purposes.

A cathode-ray oscilloscope was connected to the grid circuit of the receiver kinescope to allow further visual indication of the interference caused by the transmitter when the closely coupled grounded-trap circuits were detuned. Under such conditions the pattern on the kinescope was a maze of interference and the CRO tube showed a pattern with both rf and 60-cycle components present at the grid of the kinescope. All these patterns disappeared when the grounded plate traps were properly tuned. The shunt traps in series with the plate circuits of the two tubes needed only to be tuned to the inductive side of resonance of the unwanted harmonic. This tuning was not critical. To obtain the results described, the grounded-trap coil should be located at the hot end of the tank coil and wound on the same form and in the same direction. Ground the trap coil at the far end, away from the tank coil.

It is realized that a complete test requires that the TVR be tuned to a television station signal in order to determine if any interference may still be present that could not be detected under the test conditions outlined above. Such tests are underway and will be discussed in the next article of this series.

[1] Radio Engineers Handbook, FE Terman, Fig. 86
[2] "I.-bus and Reder", Proc. IRE., Vol. 19, pp 949-962, 1931
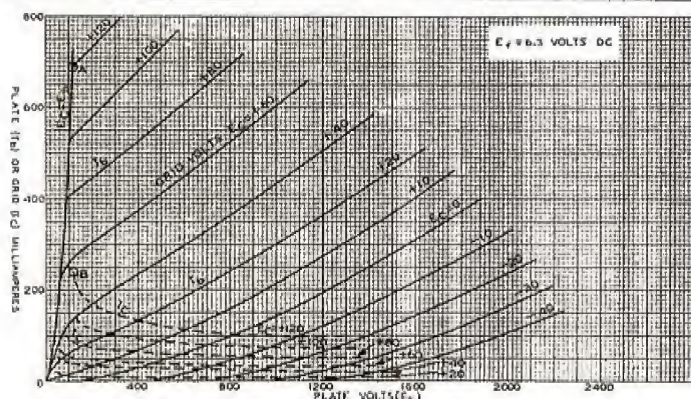[3] RMA publication R4-2860-A (July 1948) by W. T. Wintringham.
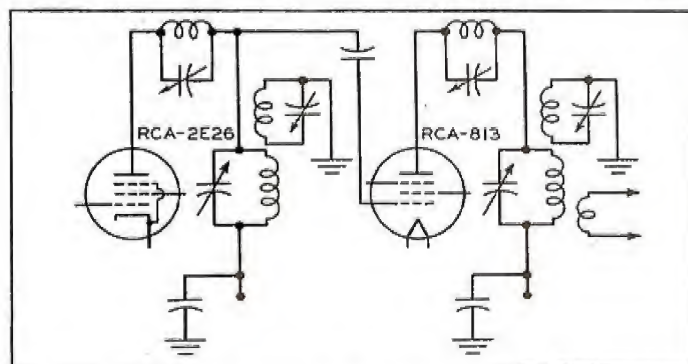
Figure 5. The 812-A characteristic curves.

Figure 3. Schematic of method devised to cancel transmitter harmonics.

AF POWER AMPLIFIER & MODULATOR—Class B

Maximum Ratings, *Absolute Values:*

	CCS		ICAS		
DC PLATE VOLTAGE	1250 max.		1500 max.		volts
MAX.-SIGNAL DC PLATE CURRENT*	175 max.		175 max.		ma
MAX.-SIGNAL DC PLATE INPUT*	165 max.		235 max.		watts
PLATE DISSIPATION*	45 max.		65 max.		watts

Typical Operation:

Values are for 2 tubes

	CCS		ICAS		
DC Plate Voltage	1250	....	1500	....	volts
DC Grid Voltage#	−40	....	−48	....	volts
Peak AF Grid-to-Grid Voltage	225	....	270	....	volts
Zero-Signal DC Plate Current	22	....	28	....	ma
Max.-Signal DC Plate Current	260	....	310	....	ma
Effective Load Resistance (plate-to-plate)	12200	....	13200	....	ohms
Max.-Signal Driving Power (Approx.)	3.5	....	5	....	watts
Max.-Signal Power Output (Approx.)	235	....	340	....	watts

PLATE-MODULATED RF POWER AMP.—Class C Telephony

*Carrier conditions per tube for use with
a max. modulation factor of 1.0*

Maximum Ratings, *Absolute Values:*

	CCS	ICAS	
DC PLATE VOLTAGE	1000 max.	1250 max.	volts
DC GRID VOLTAGE	−200 max.	−200 max.	volts
DC PLATE CURRENT	125 max.	150 max.	ma
DC GRID CURRENT	35 max.	35 max.	ma
PLATE INPUT	115 max.	175 max.	watts
PLATE DISSIPATION	30 max.	45 max.	watts

Typical Operation:

DC Plate Voltage	1000	....	1250	....	volts
DC Grid Voltage	−110	....	−115	....	volts
From a grid resistor of	3400	....	3300	....	ohms
Peak RF Grid Voltage	220	....	240	....	volts
DC Plate Current	115	....	140	....	ma
DC Grid Current (Approx.)	33	....	35	....	ma
Driving Power (Approx.)	6.6	....	7.6	....	watts
Power Output (Approx.)	85	....	130	....	watts

RF POWER AMPLIFIER & OSC.—Class C Telegraphy

Key-down conditions per tube without modulation# #

Maximum Ratings, *Absolute Values:*

	CCS	ICAS	
DC PLATE VOLTAGE	1250 max.	1500 max.	volts
DC GRID VOLTAGE	−200 max.	−200 max.	volts
DC PLATE CURRENT	175 max.	175 max.	ma
DC GRID CURRENT	35 max.	35 max.	ma
PLATE INPUT	175 max.	260 max.	watts
PLATE DISSIPATION	45 max.	65 max.	watts

Typical Operation:

DC Plate Voltage	1250	....	1500	....	volts
DC Grid Voltage:					
From a fixed supply of	−90	....	−120	....	volts
From a grid resistor of	3000	....	4000	....	ohms
From a cathode resistor of	530	....	590	....	ohms
Peak RF Grid Voltage	200	....	240	....	volts
DC Plate Current	140	....	173	....	ma
DC Grid Current (Approx.)	30	....	30	....	ma
Driving Power (Approx.)	5.4	....	6.5	....	watts
Power Output (Approx.)	130	....	190	....	watts

*   *Averaged over any audio-frequency cycle of sine-wave form.*

\#   *Grid voltages are given with respect to the mid-point of filament operated on ac. If dc is used, each stated value of grid voltage should be reduced by one-half the filament voltage and the circuit returns made to the negative end of the filament.*

\# \#   *Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.*

Figure 6. General data for the 812-A.

SIMPLIFIED CALCULATIONS

(Continued from Page 3, Column 2)

Therefore, the average grid current
$$I_c = 0.220 \times 0.175 = 0.038 \text{ amperes}$$
and the driving power
$$P_d = 0.9 \times 236 \times 0.038 = 8.0 \text{ watts}$$

A comparison between these calculated values and the published data for the 812-A is shown in Table 1 below.

It can be seen from this comparison that for practical purposes there is a satisfactory agreement between published and calculated values.

Class B Operation (Audio Frequency)

For class B audio operation it may be assumed E_b and I_b are given. In this case, I_b is the plate current for both tubes of the push-pull amplifier.

TABLE 1. (class C)

	Calculated Values	Published Data
DC Plate Voltage (E_b)	1500	1500 volts
DC Grid Voltage (E_c)	−116	−120 volts
Peak RF Grid Voltage (e_g)	236	240 volts
DC Plate Current (I_b)	173	173 ma.
DC Grid Current (I_c)	38	30 ma.
Driving Power (P_d)	8.0	6.5 watts
Power Output (P_o)	205	190 watts

Then, peak plate current for two tubes $i_b = 1.57 I_b$ (7)

At the value of i_b given by (7) we determine the peak grid voltage e_c and the peak plate voltage e_b on the $E_c = E_b$ curve.

The following formulas apply:

Power output for two tubes,
$$P_o = 0.78 (E_b - e_b) I_b \text{ (watts)} \quad (8)$$

Plate loss per tube,
$$P_p = \tfrac{1}{2}(E_b I_b - P_o) \text{ (watts)} \quad (9)$$

The grid bias should be chosen so that at E_b, a zero-signal current flows which produces a plate dissipation of about 1/3 the rated dissipation. Thus, if each tube is rated to dissipate P'_p watts,

Zero-signal plate current for two tubes = $I'_b = \dfrac{2P'_p}{3E_b}$ (amperes)   (10)

The bias required for this plate current can be found from the characteristic curves. The peak grid drive per tube is then the sum of the bias and e_c ($=e_b$) which was determined for equation (8).

Peak grid-to-grid driving voltage
$$= e_g = 2(e_c + E_c) \text{ (volts)} \quad (11)$$

The required plate-to-plate load resistance
$$R_L = \frac{2.6 (E_b - e_b)}{I_b} \text{ (ohms)} \quad (12)$$

The maximum-signal driving power for two tubes,
$$W_d = \frac{i_c e_g}{4} \text{ (watts)} \quad (13)$$

where i_c is the grid current in amperes at the point found for equation (8).

Example

Again consider the typical operating conditions given in the published data for the 812-A as a class B AF power amplifier in ICAS service. The data given are $E_b = 1500V$, $I_b = 310$ ma. or 0.310 amperes (2 tubes).

Then the peak plate current $i_b = 1.57 \times 310 = 487$ ma.

From the $E_c = E_b$ curve in Figure 5 we get 487 ma. at $e_c = 90$ volts and $e_b = 90$ volts.

Then from equations (8), (9), and (10), power output for two tubes $P_o = 0.78 (1500 - 90) 0.310 = 340$ watts. Plate loss per tube

$P_p = \tfrac{1}{2}(1500 \times 0.310 - 340) = 62.5$ watts. Zero-signal plate current for two tubes
$$I'_b = \frac{2 \times 65}{3 \times 1500} = 0.029 \text{ amperes.}$$

The required bias for a plate current (per tube) of 14.5 ma. at 1500 volts can be found from Figure 5 and is about −48 volts.

Then from equation (11),

Peak grid-to-grid driving voltage $e_g = 2(90 + 48) = 276$ volts.

From equation (12), plate-to-plate load resistance $R_L =$
$$\frac{2.6 \times (1500 - 90)}{0.310} = 11{,}800 \text{ ohms}$$

To get the driving power, we first need the peak grid current at $e_c = e_b = 90$ volts. This value is obtained from Figure 5 and is 130 ma. or 0.130 amperes. Then, driving power for two tubes
$$P_d = \frac{0.130 \times 276}{4} = 9 \text{ watts.}$$

The calculated values may now be compared with the 812-A published data, as shown in Table 2 below.

Again, the approximate calculations give results in good agreement with the published data.

[1]For a derivation of these formulas, refer to "Simplified Methods for Computing Performance of Transmitting Tubes", W. G. Wagener, Proc. IRE., Vol. 25, No. 1, January 1937, pp 47-77.

TABLE 2. (class B audio)

	Calculated Values	Published Data
DC Plate Voltage (E_b)	1500	1500 volts
DC Grid Voltage (E_c)	−48	−48 volts
Peak AF Grid-to-Grid Voltage (e_g)	276	270 volts
Zero-Signal DC Plate Current (I'_b)	29	28 ma.
Max.-Signal DC Plate Current (I_b)	310	310 ma.
Effective Load Resistance (Plate to Plate) (R_L)	11,800	13,200 ohms
Max.-Signal Driving Power (P_d)	9	5 watts
Max.-Signal Power Output (P_o)	340	340 watts

A PRACTICAL METHOD FOR REDUCING HARMONIC RADIATION

"TIN-CAN" WAVEMETER
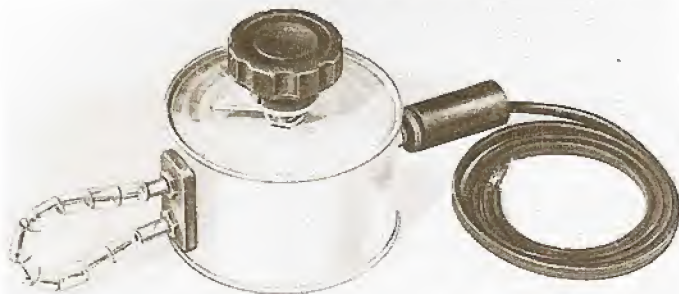
Despite its humble origin, this easily built but extremely sensitive absorption type wavemeter is a "must" for tracking down offending harmonic radiation in transmitters.

SELF-CONTAINED VFO DESIGNED FOR STABILITY ON ALL BANDS

By ANDREW RAU, JR., W3KBZ
RCA Tube Department

Even a confirmed proponent of crystal-controlled operation will concede that under present-day crowded band conditions, a really stable variable-frequency oscillator is indispensable. The completely self-contained VFO described in this article includes a regulated power supply, provision for oscillator keying, band spread on the higher-frequency bands, control circuits for the receiver and transmitter, and coupling by means of coaxial cable to the crystal socket of the transmitter. This method of coupling permits locating the high-power rf section away from the operating position.

A really satisfactory VFO has two basic requirements. The first of these requirements is relative freedom from drift or instability, and the second is the ability to key without chirps or other transient effects. A careful choice of components with due consideration to layout, along with a "workmanlike" mechanical job will go a long way toward meeting the first requirement. The recently publicized Clapp circuit [1] will assist in satisfying the second requirement.

Frequency Drift Considerations

In addition to the effects of component choice, layout, and workmanship, the most troublesome factors contributing to the instability of a self-excited oscillator are the effects of humidity, temperature, and changes in operating conditions such as voltages, currents, etc. The effect of humidity can be minimized by the use of high-quality components of ceramic or other low-loss material in the rf portions of the circuit. The effects of temperature are most satisfactorily minimized through the use of a frequency-determining coil wound on a ceramic form large enough to give a high "Q" but which will undergo little change of inductance with temperature. In addition, the main tuning capacitor should be of sturdy construction with small plates well spaced in a frame with ceramic end plates and with two bearings. All other capacitors should be silver mica or ceramic types with a low temperature coefficient.

Because fundamentally it is desirable to obtain maximum "Q" in the oscillator tank circuit, it is important to make all rf connections in this circuit as short and direct as possible. Moreover, it is undesirable to depend on a steel chassis to conduct rf tank currents because

USING TUNED FEEDBACK CIRCUITS TO CANCEL TRANSMITTER HARMONICS

By JOHN L. REINARTZ, W3RB
RCA Tube Department

In the previous article on this subject it was pointed out that the generation of Harmonics in a class C stage is natural and must be expected. In fact, it is this harmonic generation that makes doubler and tripler stages possible. However, if the radiated power capable of causing interference must be kept to less than 0.01 microwatt, even such high order harmonics as the 8th or 16th from fundamental operation at 7 or 3.5 Mc may cause television interference. Even more trouble can be expected from stages operating at 14 and 28 Mc where the harmonic order that can cause interference is much lower and the amplitude much higher. The problem then is —what to do about these harmonic radiations that cause TVI.

What To Do About It

In Part I, it was pointed out that previous investigators advocated the use of complete shielding along with the installation of parallel-tuned series-inserted traps [1] and other bypassing devices which must also be shielded. The writer, however, has had considerable success with another method of reducing harmonic radiation which does not depend upon shielding for its efficacy. This method involves the use of the tank-coil traps described in Part I but with one additional and important refinement in the method of connecting the traps together and grounding them. These tank-coil traps operate by absorbing unwanted harmonics and cancelling them out by means of tuned feedback circuits. But more of this later. Our first problem is to locate the offending harmonics.

Locating the Harmonic

In order to use this method, we must first locate the offending harmonic and utilize some method of measuring its relative amplitude. For this purpose an old standby, the universally used absorption-type wavemeter, comes into play.

A modified wavemeter that has proved extremely sensitive was devised by the writer. This unit, diagrammed in Figure 1, consists of a resonant circuit (L_1C_1) for the frequencies under discussion, a 4-turn $\frac{1}{4}$" diameter coil of #20 enamelled insulated wire (L_2) in series with the resonant circuit, a 1N34

STURDY AND STABLE
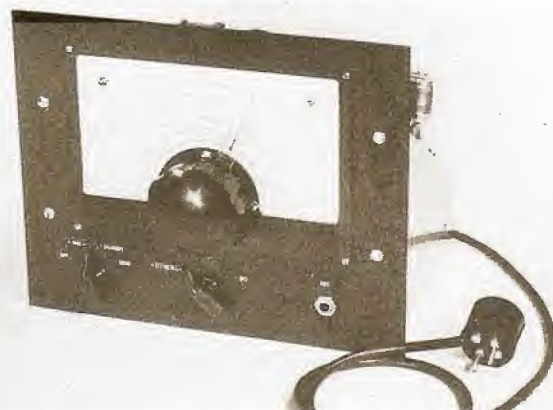
Completely self-contained, this efficient looking VFO has its own power supply, provision for oscillator keying, band spread on the higher-frequency bands, control circuits for both receiver and transmitter, and coupling by coaxial cable to the transmitter crystal socket.

HARMONIC OUTPUT

(Continued from Page 1. Column 4)

crystal and microammeter in series connected across the 4-turn coil, and a capacitor (C_2) connected across the meter. The microammeter is connected to the tuned circuit by means of a flexible two-wire cord of any desired length. This arrangement allows the operator to get much closer to circuits suspected of harmonic radiation than would be the case if the resonant circuit and the meter were in one container. The absorption meter may be built into a small metal can into which the pick-up loop for the particular frequency

L₁   10 turns #20 ECW, wound with ½" dia.
C₁   3-30 μμf
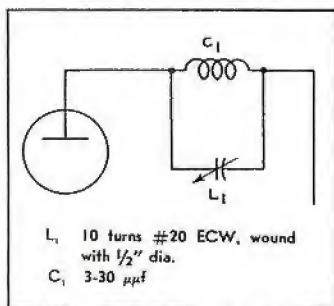
Figure 2. A parallel-tuned trap circuit.

range desired can be plugged. A photograph of the wavemeter is shown on Page 1. When a variable capacitor of 3.5 to 75 μμf is used together with a pickup loop 2" long, consisting of a single hairpin turn, the tuning range extends from 50 to 150 megacycles.

The hairpin pickup loop should be threaded with glass or porcelain beads or with some other insulating material so that when the wavemeter is used to probe near high-voltage points, direct contact will be prevented. An additional, but very worthwhile precaution is to connect a flexible grounding wire between the wavemeter can and ground.

Because the 4-turn coil is inside the can, it picks up very little energy from the fundamental frequency when the wavemeter hairpin is held close to a tank circuit.

Preliminary Checking

The next thing to do is to make a preliminary check with the wavemeter to determine which harmonics are prevalent in the transmitter and where they are most prominent. A good place to check is near the plate connection of each tube. Caution must be exercised when high-voltage points are checked in order to prevent any accidental contact.

As the check for harmonics progresses, make a note of the location and relative value of the harmonics for future reference. Don't be surprised if harmonic indications are noted in the heater leads of heater-cathode-type tubes or at that end of a plate-tuning-capacitor frame which is not bypassed for rf ground. In order to cut down the harmonics at these points, connect a bypass

capacitor of 0.001 μf and the proper voltage rating between the plate-tuning-capacitor frame and ground. Between the heater lead and ground use a 0.01 μf capacitor. A further check with the wavemeter at these points will in all probability show a substantial reduction in the harmonic amplitude. Any long lead under a chassis may also show harmonic voltages and should be similarly bypassed at readily accessible points.

Tuned-Plate Traps

After adequate bypassing is accomplished, the first step is to insert parallel-tuned trap circuits in series with the plate leads of each class C stage. See Figure 2. These traps may be made readily with ten turns of #20 enamel coated wire, wound with a ½-inch inside diameter and shunted with a 3- to 30-μμf trimmer capacitor for tuning. It will be found that the tuning range of this trap extends from 25 to 80 Mc.

Tank-Coil Traps

The next step, which is something new in TVI reduction, is to utilize the previously mentioned tank-coil traps which absorb and cancel through negative feedback the unwanted frequencies. These traps are positioned about ¼" from the hot end of the plate tank coil at each stage. Each trap (see Figure 3) is made by winding a coil of as many turns as can be made with 18 inches of wire in the same direction and of the same diameter as the tank coil.

Wire comparable in size to that of the tank coil should be used although it is not necessary to use wire larger than #10. The coil is then shunted with a 3- to 50-μμf tuning capacitor. The hot end of the coil is connected to the stator plate. This capacitor is mounted adjacent to but not more than 2" to 3" from the coil in such a manner as to be tunable from the front panel by means of an extension shaft. The rotor side of the variable capacitor is then grounded. Similar traps are mounted at the
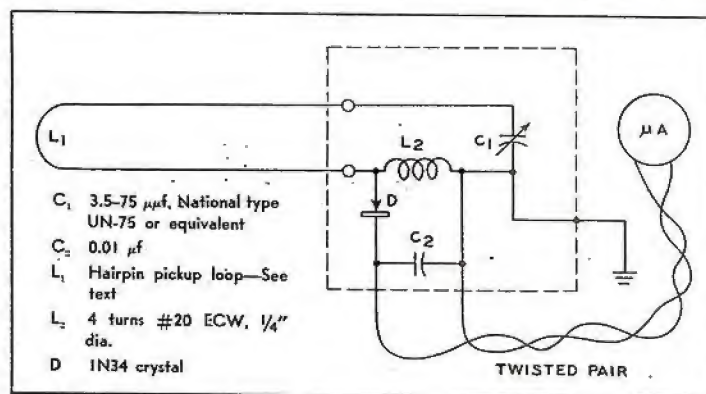
hot ends of the other plate tanks and the antenna coil as shown in Figure 4. Each trap is then coupled by means of a 25-μμf fixed capacitor to a common line which is grounded at a point approximately half way between any pair of 25-μμf fixed capacitors.
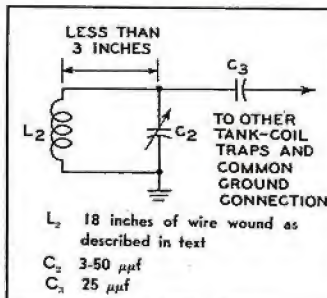

L₂   18 inches of wire wound as described in text
C₂   3-50 μμf
C₃   25 μμf

Figure 3. A tank-coil trap circuit.

Connecting the Grounding Wire

A final connection completes the hookup. This connection is made to the trap in the tank circuit of the final and consists of a grounding wire approximately ten inches long connected between the ungrounded side of the variable tuning capacitor and any convenient point on the chassis. Some experimentation may be necessary to locate the optimum grounding

LOOKING INSIDE

An interior view of the wavemeter shows placement of components. The rotor plates of the variable capacitor may be trimmed in order to make the frequency response of the unit more linear at the high-frequency end.

point necessary to produce maximum harmonic attenuation.

In push-pull stages only one tank-coil trap is required. If either a center-tapped antenna tuning unit or a split tank circuit is used, the tank-coil trap may be located at either end.

Shielding Considerations

Although the operation of this system of reducing harmonic interference does not specifically require shielding, it is advantageous to use a metal front panel in addition to the usual metal chassis. The metal front panel minimizes the detuning effects of hand and body capacitances when the several air capacitors are adjusted.

Tune Up

The tune-up procedure is quite simple. The absorption-type wavemeter is tuned to the lowest harmonic causing TVI. It is then brought in close proximity to the tank circuit of the first stage in the equipment and the series-inserted plate trap is tuned to reduce the offending harmonic to a minimum. It will be found that several minimums will be noted as the 3- to 30-μμf trimmer capacitor is adjusted from minimum capacitance to maximum capacitance. In the doubler and final stages, however, care must be taken to avoid tuning to the output frequency so that the 3- to 30-μμf capacitor will not tend to arc over and burn up. After testing over the entire range with the wavemeter, choose the setting at which all harmonics, even and odd, above and including the offending harmonic are reduced to a minimum. The tank-coil trap is then tuned for still further harmonic reduction. The process is repeated for each stage, in order, ending with the antenna-tuning stage. A further check is made at the antenna feeders to make sure that no harmonic emission is detectable. The final, and most important check, of course, should be made on the nearest television receiver.

Field Tests

In several rigorous field tests, this system of reducing TVI gave excellent results. One test was made

---

Figure 1. Wavemeter schematic.

C₁   3.5-75 μμf, National type UN-75 or equivalent
C₂   0.01 μf
L₁   Hairpin pickup loop—See text
L₂   4 turns #20 ECW, ¼" dia.
D   1N34 crystal

C₁   3-30 μμf, National type M-30 or equivalent
C₂   3-50 μμf, Cardwell type ZR-50-AS or equivalent
C₃   25 μμf, mica, "postage stamp" type

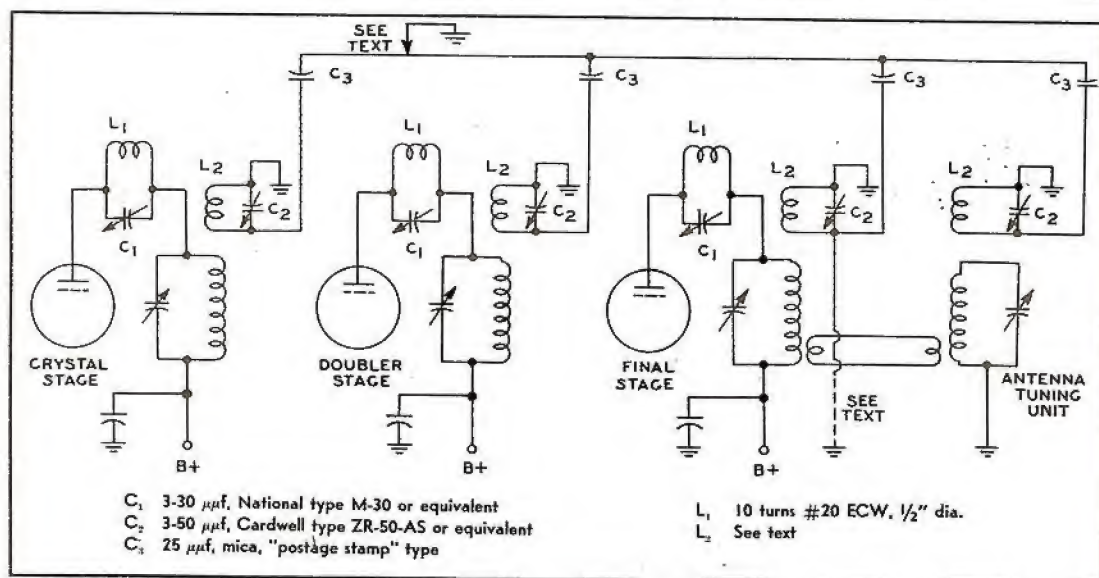L₁   10 turns #20 ECW, ½" dia.
L₂   See text

Figure 4. Partial schematic of transmitter showing manner in which harmonic-cancelling traps are placed in circuit.

HARMONIC OUTPUT

(Continued from Page 2, Column 4)

at the writer's home station in Lancaster, Pa. The regular 20-meter folded dipole 45 feet high was located within 50 feet of the television antenna also 45 feet high. The transmitter was operated with 300 watts input and caused no interference on channels 3 and 6 originating in Philadelphia 65 miles away. For these tests the TV screen was viewed at a distance of approximately 40 inches in order to obtain the standard 4-to-1 viewing ratio for a 10-inch kinescope.

For a more strenuous test, the transmitter was then taken to Harrison, N. J., where it was operated in the same room with a commercial television receiver. All 6 channels in the New York area were sampled and were clear of transmitter interference to a degree considered unattainable before the tests began.

In Lancaster, the system was tried and is still in use on a Collins 32V transmitter operating on 10 meters with equally satisfactory results.

Although this system has worked remarkably well in every transmitter the author has modified, it should be recognized that each case of TVI presents special problems and requires experimentation.

(¹) Mack Seybold "Curing Interference to Television Reception," QST, August 1947 Vol. XXXI, No. 8, pp 19-23.

ECHOES

The High-Fidelity Audio Amplifier described in the September-October 1948 issue of HAM TIPS inadvertently listed C12 as a 0.01 uf capacitor. Actually the capacitance should have been shown as as 0.1 uf.

VFO UNIT

(Continued from Page 1, Column 2)

the high rf resistance of the chassis will cause a substantial reduction in "Q".

A large portion of the drift due to temperature changes results from expansion, twisting, and warping of the chassis and panel. The heavier the chassis and panel are, however, and the more substantially they are fastened together, the less the frequency drift will be. To appreciate fully the order of stability required, it should be remembered that a shift of only 500 cycles will be 4000 cycles when multiplying from the 3.5-Mc band to 28 Mc. Also, it is not uncommon for receiver oscillators, particularly of the broadcast variety, to drift as much as several thousand cycles.

Frequency drift due to changes in operating conditions is minimized by using a well-regulated power supply.

Circuit Details

Excellent descriptions of the Clapp oscillator circuit are given in the references and need not be repeated here. The complete circuit of the VFO is given in Figure 5, on Page 4. The frequency-determining circuit consists of L₁, C₇, C₈, and the series-parallel combination of C₁ to C₆, all in series. Because the capacitive reactance of C₁ to C₆ cancels a portion of the inductive reactance of L₁, a relatively large inductance may be used. This large inductance, plus the fact that the 6AG7 grid No. 1 is effectively tapped across only a portion of the tank circuit, provides a circuit with extremely high "Q". When the 6AG7 is connected as an electron-coupled oscillator, it is possible to use a considerably larger coil for L₁ with a further reduction in the effects of voltage and tube changes on frequency stability. However, if such a circuit is used, the actual

tuning capacitance becomes smaller and the effects of temperature and mechanical changes in the chassis and tank circuit are much greater.

Switch S₁ is used in one position (A) for the 3.5-Mc band. In the other position (B) the higher-frequency bands are spread out when multiplying in later stages to 7 Mc and higher. C₅ is the main tuning capacitor while C₄ and C₆ are the band-spread padders. Considerably greater band spread could be obtained if the 11-meter band were not included. C₃ is the 3.5 Mc band-set capacitor. C₁ and C₂ compensate to some degree for changes in temperature. The oscillator operates with a screen current of about 1.5 ma at 75 volts and a plate current of only 5 ma at 180 volts. Keying of the cathode circuit causes no perceptible change in frequency, and no chirp nor other transient.

The 6AG7 was selected as a class A buffer because, due to its high transconductance, it is capable of about 3 watts output with negligible grid power or voltage requirements.

Across a 10,000-ohm load, about 70 volts are developed at the output connections of this circuit. This voltage is more than sufficient to drive the regular crystal stage of a transmitter.

The buffer amplifier plate and screen currents total about 20 ma with the plate operating at 250 volts. A low-value coupling capacitor (C₁₂) plus the use of dropping resistor R₂ prevents the following stages from affecting the oscillator frequency. In fact, the frequency shift, from full load to no load (complete disconnection of the co-axial output lead) is only one or two cycles. The output circuit, L₂ link-coupled through a coaxial feeder to L₆, is low in capacitance and gives nearly uniform output over the entire 3.5-Mc band when C₁₆ and C₁₇ are stagger tuned.

The voltage-regulator tubes largely eliminate the effect of variations in line voltage. A decrease of 20 volts in line voltage causes less than a 10-cycle shift in frequency. The power supply, conventional in design, has a total drain in the order of 50 ma. Because it is often desirable to provide complete control of the rig from the VFO unit, switch S₂ was added to provide switching circuits for the receiver and the power relay of the transmitter final. The standby position of the switch permits checking the oscillator frequency before the final is in operation.

Construction Details

Ample room is provided by a 7" x 9" x 2" chassis, preferably of aluminum, with welded or reinforced corners. If an 8" x 10" panel is used, the VFO will fit several types of small standard cabinets. Home-made side brackets of aluminum rigidly tie the panel and chassis together and, to a large degree, prevent warping and twisting. A National type ACN dial is directly calibrated for each band. A "U"-shaped aluminum bracket supports the main tuning capacitor at the front and rear more rigidly than the brackets

BEHIND-THE-PANEL VIEW
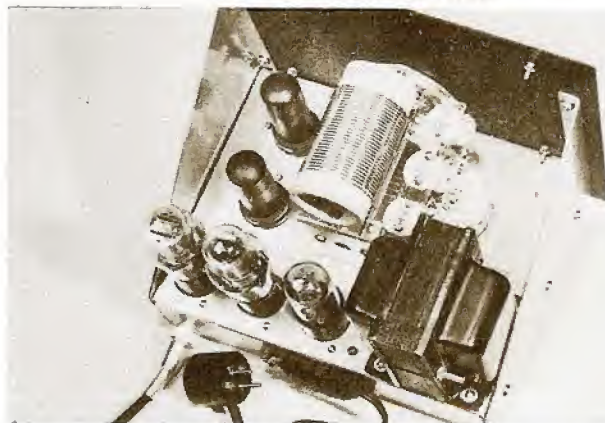
Well planned design of the VFO provides ample space for mounting components. Band-spread and padder capacitors are fixed to a 4-inch strip of polystyrene shown in center of photograph.
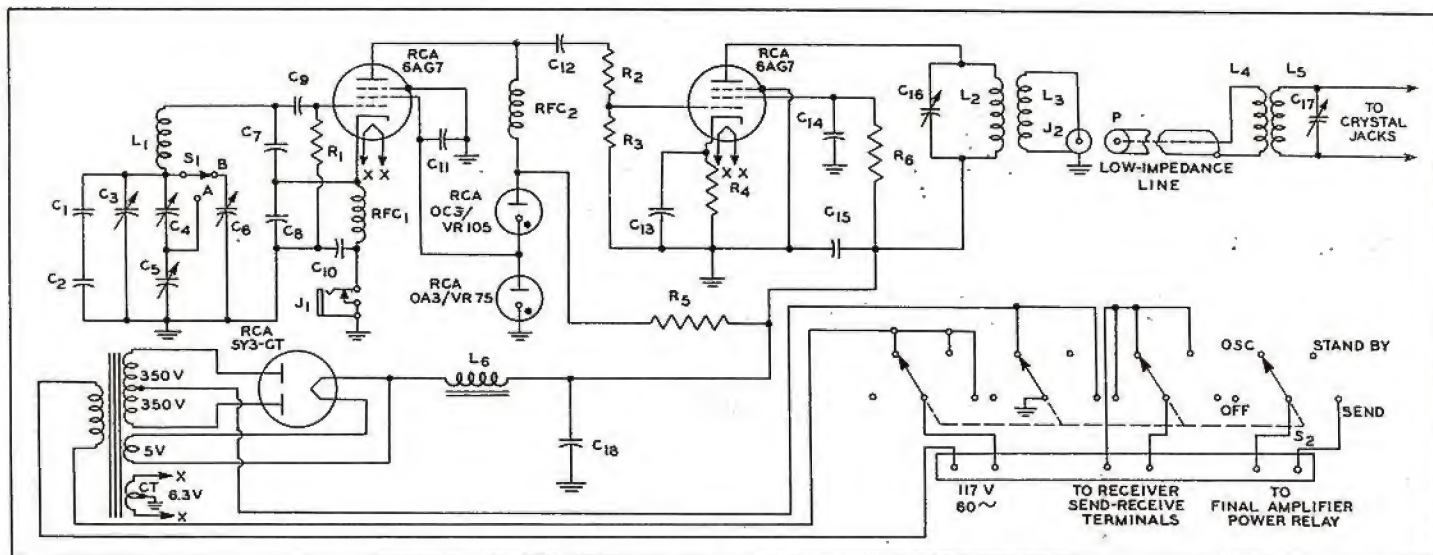
Figure 5. Schematic of variable frequency oscillator.

VFO UNIT

supplied with the capacitor. In addition, the aluminum bracket provides a support for the coil clear of the chassis and panel thereby reducing the effect of temperature changes. The band-spread and padder capacitors are mounted on a 4-inch strip of polystyrene attached to the side of this bracket. (See photograph on page 3.)

Switch S_1 is mounted face down with the shaft extending through a hole in the top of the chassis. It is controlled from the front panel by means of a flexible shaft. The power supply components are mounted along the rear of the chassis with the filter choke on the underside. The 6AG7 oscillator is directly behind the panel. The two 6AG7 tube sockets are oriented for the shortest possible connections. Except for the usual considerations of providing good mechanical rigidity, short leads, and bringing the rf returns for each stage to a common point, the wiring is simple and not critical. No trouble should be experienced with self oscillation.

L_2 is wound on a medium-sized octal tube base from which the pins have been removed. The tube base is then fastened to the chassis by means of a screw through the bakelite positioning plug. Capacitor C_{16} is mounted inside the coil. A three-turn link (L_3) wound on L_2 at the low-voltage end is connected to receptacle J_2. A suitable length of B & W Miniductor (one-inch diameter and having 32 turns per inch) may be substituted for L_2 if desired. A low-impedance transmission line of any reasonable length connects the output jack to L_5 and L_4. Because high "Q" was not particularly desired for L_4, it was random wound on a form together with L_5, its three-turn link, and inserted in a four-pin tube base with the pin spacing altered to fit the standard crystal pin spacing. If room permits, however, the use of a suitable plug-in type coil form will simplify the construction.

The frequency drift, even without temperature compensation, will not be excessive. Some adjustment of the degree of compensation, however, may be desirable and can be easily accomplished by changing the value of capacitor C_1. Any check of the keying characteristics should include listening on one of the higher-frequency bands because

any defects will be considerably accentuated by frequency multiplication.

[1] J. K. Clapp, "An Inductance-Capacity Oscillator of Unusual Frequency Stability." Proc. I. R. E., March 1948. "Technical Topics." May and Oct. 1948 QST. Nicholas Lefor, "The 'Topics' VFO." Aug. 1948 QST.

PARTS LIST

C1	15 uuf, zero temperature, Centralab style NPO
C2	100 uuf, negative temperature, Centralab style N750
C3	6-75 uuf, Hammarlund type APC-75 or equivalent
C4	7-100 uuf, Hammarlund type APC-100 or equivalent
C5	10-75 uuf, Bud #CE-2014 or equivalent
C6	3-50 uuf, Hammarlund type APC-50 or equivalent
C7, C8	0.001 uf, silver mica
C9	100 uuf, silver mica
C10, C11, C13, C14, C15	0.005 uf, mica
C12	15 uuf, silver mica
C16, C17	3-30 uuf, mica
C18	20 uf, 450 working volts, electrolytic

R1, R3	100,000 ohms, ½ watt
R2	27,000 ohms, ½ watt
R4	100 ohms, ½ watt
R6	15,000 ohms, 1 watt
R5	2,000 ohms, 10 watts
T1	Transformer, 350-0-350 volts at 90 ma., 5 volt. at 2 amps, 6.3 v at 3.5 amps. Thordarson No. T17R37 or equivalent
L1	28 turns, No. 18 enamel, spaced over 2⅜", on 1¾" dia x 3½" National No. XR13 Ceramic coil form or equivalent
L2	No. 26 enamel close wound 1⅛" on 1 5⁄16" dia. form. B & W Miniductor (Cat. 3016) may be substituted
L3	3-turn link wound on L2 at low-voltage end.
L4	56 turns No. 26 enamel, random wound approx. ¾" on 1⅛" dia. form
L5	3-turn link, wound on L4
RFC1, RFC2	Choke, 2.5 mh, 125 ma
L6	Choke, 8-24 henry, 80 ma, Thordarson No. T20C53 or equivalent
S1	Switch, 4-position, 1-section Mallory Hamband switch.
S2	Switch, 2 gang, 4 circuit, 4-point rotary
J1	Closed circuit jack for key
J2	Coaxial receptacle
P	Coaxial plug

VFO UNDER-CHASSIS
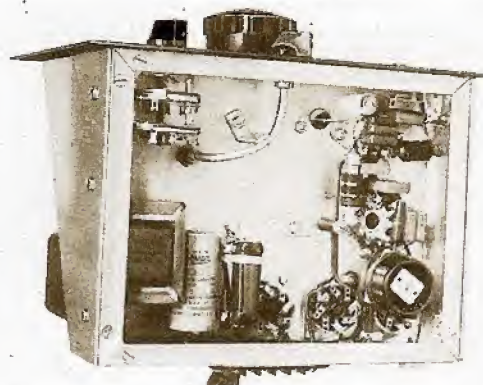
Aside from the usual considerations of providing mechanical rigidity, short leads, and bringing rf returns for each stage to a common point, the wiring of the VFO is simple and not critical.

"TINY TRAN" - A MINIATURE RIG FOR 10 AND 11 METERS

FREQUENCY MULTIPLIER

Requiring only one ganged-tuning control, the all band frequency multiplier makes shifting from one band to another a simple operation. Its design provides compactness and good shielding to minimize TVI.

ALL BAND FREQUENCY MULTIPLIER IS GANGED TUNED FOR RAPID QSY

By
GEORGE D. HANCHETT, JR., W2YM
RCA Tube Department

The increasing popularity of 80-meter VFO's has stimulated the need for a companion unit, a frequency multiplier, which can be used with the VFO to operate on all the lower frequency bands: 80, 40, 20, 15, and 10-11 meters. Such a unit, designed to work with the VFO described in the last issue of HAM TIPS,† is the subject of this article. Its design, in addition to providing the usual desirable qualities of simplicity and compactness, features good shielding for a minimum of TVI.

Because the multiplier requires only one ganged tuning control, shifting from one band to another is a very simple operation. Although a preliminary design of this multiplier employed broadband tuned circuits in order to eliminate the one tuning control, tests indicated that the broad-tuned arrangement was more likely to cause TVI than the ganged-tuned circuit.

The circuit itself is conventional. Four stages are used; a 7-megacycle doubler, a 14-megacycle doubler, a 28-megacycle doubler, and a 21-megacycle tripler.

Construction Details

An aluminum chassis 3" x 4" x 17" is used for the multiplier. All the components with the exception of the tubes and heater transformer are mounted inside the chassis. An aluminum panel, 5¼ inches wide, covers the open side of the chassis and serves as the front panel. The metal type RCA-6L6 was selected for all stages because its metal shell provides complete shielding of the tube. Another tube type could have been used with equally satisfactory results, but since it was desired to operate the multiplier from a single 350-volt supply and to obtain enough power to excite an RCA-813 as a final amplifier, the 6L6 was chosen.

The four series tracking capacitors (C_7, C_{14}, C_{21}, and C_{27}) are mounted on the top side of the chassis between the tank coils. The parallel padding capacitors (C_2, C_{10}, C_{17}, C_{23}, and C_{29}) are mounted behind each section of the ganged tuning capacitors (C_1, C_8, C_{15}, C_{22}, and C_{28}) and are available from the bottom of the chassis. The tuning control for the ganged

MOBILE TRANSMITTER DESIGNED AROUND NEW RCA-5763 PENTODE

By
MARTIN GASPIERIK, W2NEU
and
PAT PATTERSON, W2VBL
RCA Tube Department

Being avid mobile fans, originally by necessity, later by choice, the possibilities envisioned in the recently announced rf power pentode, the RCA-5763, were intriguing. The result was "Tiny-Tran", a miniature mobile transmitter for 10 and 11 meters. This 5 x 9½ x 2½ inch rig operates with a plate input power to the final of 15 watts at 27 to 30 Mc. The heater drain is only 2.7 amperes at 6.0 volts and the plate supply 140 ma at 300 volts.

Let's take a look at the output tube first. The 5763 is a 9-pin miniature transmitting type, capable of 15 watts input up to 175 Mc. The high-perveance characteristic is particularly suitable for mobile operation because it considerably reduces power supply problems. Another important feature is the heater rating. The cathode is so constructed as to give full emission with only 6.0 volts applied to the heater. Heater voltage is an important consideration in mobile work since, more often than not, the battery voltage less the line drop approximates this 6-volt figure.

Quite naturally, its size, too, is interesting, since the 5763 is only slightly larger in diameter than the 7-pin miniature 6AQ5. When the 5763 is used in the rf stages, and other miniatures are used in the audio stages, economy of space is at a maximum.

The heater requirements and maximum ratings of the RCA-5763 are as follows:

Heater Voltage (ac or dc)	6.0 ± 10% volts
Heater Current	0.75 ampere
DC Plate Voltage	300 max. volts
DC Grid-No. 3 (Suppressor) Voltage	0 max. volts
DC Grid-No. 2 (Screen) Voltage	250 max. volts
DC Grid-No. 1 (Control-Grid) Voltage	125 max. volts
DC Plate Current	50 max. ma
DC Grid-No. 2 Current	15 max. ma
DC Grid-No. 1 Current	5 max. ma
Plate Input	15 max. watts
Grid-No. 2 Input	2 max. watts
Plate Dissipation	12 max. watts

THE "TINY-TRAN"

Completely housed in a 5" x 9½" x 2½" chassis, this miniature transmitter is particularly suited for mobile work. It uses the new RCA-5763 rf power pentode as an output tube, and operates with a plate input power to the final of 15 watts at 27 to 30 Mc.
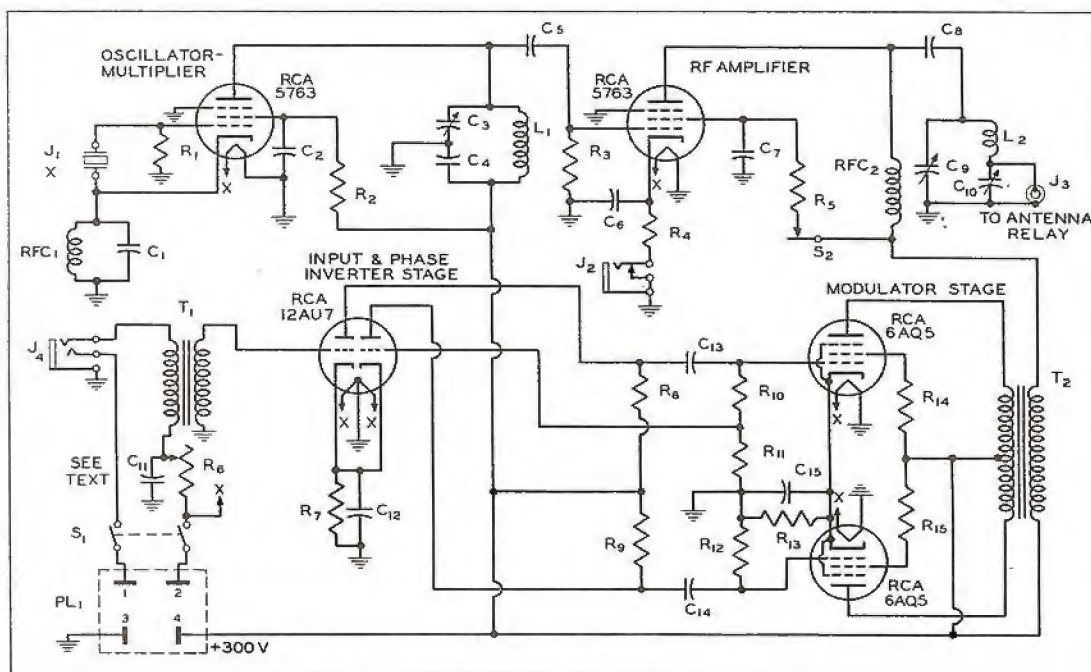
Schematic of the "Tiny-Tran"

"TINY TRAN"

(Continued from Page 1, Column 4)

Design Considerations

Because mobile operation can take place anywhere, it seemed advisable to design a unit readily adaptable to a Crosley or a Cadillac, a Piper Cub or a DC-6, a rowboat or the Queen Mary. By employing miniature tubes and small components, it was possible to place the entire circuit *inside* a small metal chassis 5 x 9½ x 2½ inches. This size and shape lends itself readily to mounting in any number of positions about the panel of a car. Even the glove compartment of most models will accommodate such a box. All controls are brought to the front panel with the exception of the meter jack, which is brought out in the rear.

The bottom plate of the chassis becomes the side panel, and gives access to the "innards" of the rig by removal of the self-tapping screws. Two sub panels are cut to fit as indicated in the photographs. The lower panel holds the audio stages, while the upper one supports the rf unit. Some of the components are mounted directly on the chassis, but, despite cramped quarters, all parts and wiring are quite accessible.

Because the 5763 is designed to operate at a high temperature (maximum 250° C) and requires good ventilation, a series of holes is drilled in the top of the case and in the cover plate directly opposite the tubes. A similar arrangement is also made for cooling the modulator stage.

RF Section

The rf section utilizes two of the new RCA-5763's, one as tritet oscillator-multiplier, and the other as an rf final amplifier. When a crystal in the order of 7 Mc is used,

ample drive to the grid of the final at 28 Mc is obtained readily.

An important space-saving feature is the tritet coil which is a commercial rf choke, the size of a one-watt resistor. The inductance and Q requirements of this coil are met very satisfactorily by the Ohmite Choke, Z144.

The antenna coupling system is especially interesting because it very effectively discriminates against harmonics. (1) This type of coupling (a modified pi network) compared to the conventional link coupling, provides only ¼ of the 2nd-harmonic output, 1/9 of the 3rd-harmonic output, and proportionally smaller amounts of higher-order harmonics. Maximum loading is obtained by tuning the capacitors in the pi network. In one particular installation of this "Tiny-Tran", the antenna was fed with a 2-foot length

of 72-ohm coax line. Placement of the transmitter in the front area of the car, incidentally, allows use of a standard 4-section collapsible receiving antenna capable of being extended to 100 inches or more. This position eliminates the need for drilling holes in the rear deck of the car for the more costly police-type whips.

Audio Section

The audio section is also simple in design. An RCA 12AU7 medium-mu twin triode is used as the input phase-inverter stage, and is coupled by means of capacitors to a pair of 6AQ5's which function as class AB modulators. All operating conditions are carefully chosen so that clean, crisp speech results. This tube line-up, as in the rf section, allows either a parallel or series-parallel heater connection for 6-or

12-volt battery operation. (Most personal aircraft and some small cars use 12-volt electrical systems).

The miniature components given in the parts list are the ones used in this transmitter. Substitutions may be made if they are equivalent in size as well as electrical characteristics.

The antenna transfer relay is mounted at the base of the antenna and is controlled by the circuit that operates the dynamotor relay. Thus, when the microphone push-to-talk switch is pressed, the dynamotor is started, the antenna transferred, and voltage applied to the mike button.

Construction

The chassis, the two shelves, and the cover plate are first drilled and shaped. Next the shelves and major components are mounted inside the chassis to check their fit. The only component which requires any change in adjustments to insure a proper fit is the modulation transformer. Its rear mounting ear is bent down even with the side of the transformer shell, thus making the unit fit snugly against the rear wall of the chassis to which the transformer is bolted.

After all components fit satisfactorily, the rf and modulator shelves are removed and wiring of the transmitter started. The two shelves should be wired as completely as possible before mounting them inside the chassis. Leads leaving the shelves for connection to other components should be left sufficiently long for easy connection. The rf shelf, which contains the 5763 oscillator at the left and the 5763 amplifier at the right, should be mounted in the chassis first. Wiring for the rf section of the transmitter can then be completed. The hot heater supply lead for this section goes directly up from the main switch, S_1. The B+ supply lead goes to a 2-terminal lug strip mounted below the shelf on the mounting screw of an rf amplifier socket. The B+ end of RFC_2 is secured to a 1-terminal lug strip mounted to the right of the rf amplifier tube above the shelf. This lead is covered with a varnished cambric tubing and passed through a small hole in the rf shelf in such a manner as to bring the plate lead directly away from the grid connection. The B+ end of L_1 is also connected to a 1-terminal lug strip. All leads are kept short and a common ground point is used for each stage.

Checking The RF Section

It is suggested that the rf section be tested before mounting the audio shelf on the chassis.

For preliminary testing in the ham shack a half-wave dipole cut to frequency and center fed with a section of 72-ohm coax approximately equal in length to that used in the mobile installation should be used. Crystals between 7.125 Mc and 7.425 Mc should be used for 10-meter phone and between 6.79 Mc and 6.857 Mc for 11 meters. In-

A REAL HANDFUL
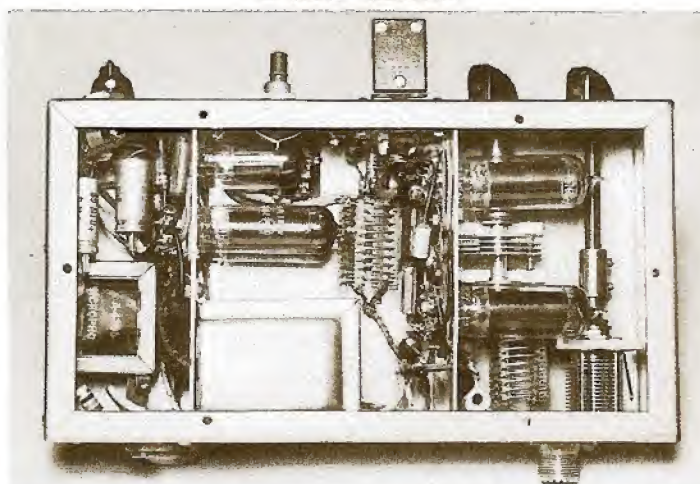
An inside view of the miniature transmitter reveals two sub panels and the manner in which parts are positioned and wired. Despite cramped quarters, all components are fairly accessible.

FREQUENCY MULTIPLIER

(Continued from Page 1, Column 2)

tuning capacitors is brought out to the front panel by means of a Millen right-angle drive shaft. The band selector switch and the on-off switch are also located on the front panel.

In order that an adjustment of the output power can be made by means of a potentiometer or rheostat on the power supply chassis or in some other convenient place, the B-supply lead to the screen grids of the 6L6's is brought out to a separate terminal on the power terminal strip. The ground connection for each stage is made at a common point for the stage and consists of a large soldering lug clamped under one of the socket mounting bolts. RF chokes RFC$_1$, RFC$_2$, RFC$_3$, and RFC$_4$, together with capacitors C$_{30}$, C$_{31}$, C$_{32}$, and C$_{33}$, are used as lead filters for the power supply to reduce the harmonic voltage on the power cable. These filters are not necessary in areas where TVI is not a problem. The circuit is designed with cathode bias so that either VFO or crystal keying may be used. No meter connections are provided because it is practical to use the grid current in the first stage of the following unit for tuning purposes.

Alignment Procedure

The alignment of the unit is relatively simple and can be accomplished in less than three minutes. The chief reason for the ease and simplicity of alignment is that adjustments are made by means of the series and parallel padding and tracking capacitors rather than by the tedious and laborious tapping of coils.

The multiplier is aligned in the following manner after the wiring has been completed but before the panel is assembled. The first stage to be aligned is the input circuit which is tuned to cover 3.4 megacycles to approximately 3.75 megacycles. First, connect the VFO to the multiplier and set the output

(Continued on Page 4, Column 1)

"TINY TRAN"

*(Continued from Page 2, Column 4)*

sert a 0-100 ma meter in the cathode circuit (J2) of the final amplifier, open switch S2, and tune the oscillator circuit for resonance by adjusting capacitor C$_5$ for the meter reading. This reading indicates grid current of the final amplifier because S2 interrupts the screen supply of the final and allows no plate or screen current to flow. When sufficient grid drive is obtained (3 to 5 ma), the rf amplifier can be operated by releasing S$_2$ and tuning C$_9$ in final tank for a dip in the cathode current. The oscillator tube draws approximately 35 ma at 300 volts.

Loading

The antenna should be cut reasonably close to the correct length for the operating frequency to prevent any difficulty in loading the transmitter. Decreasing the capacitance of C$_{10}$ increases the plate loading but, for efficient transfer of power to the antenna, the capacitive reactance of C$_{10}$ should equal the transmission-line impedance. For 72-ohm coax, C$_{10}$ should be adjusted to approximately 80 $\mu\mu$f and for 52-ohm coax, to about 100 $\mu\mu$f. If this adjustment does not provide a plate current of 45 to 50 ma (measured cathode current less 8 ma screen current and 3-to 5-ma control-grid current), decrease the capacitance of C$_{10}$ until the proper value is obtained. After each change in C$_{10}$, retune C$_9$ for maximum dip in cathode current. A further check may be made by means of a neon bulb placed at the ends of the antenna.

Adding Modulator Section

After checking out the rf portion of the transmitter, the modulator is completed. Leads on transformer T$_1$ are left sufficiently long so that the transformer may be fastened to the chassis after the bottom shelf is mounted. The leads to the secondary of the modulation transformer are connected for a plate-to-plate load impedance of 4500
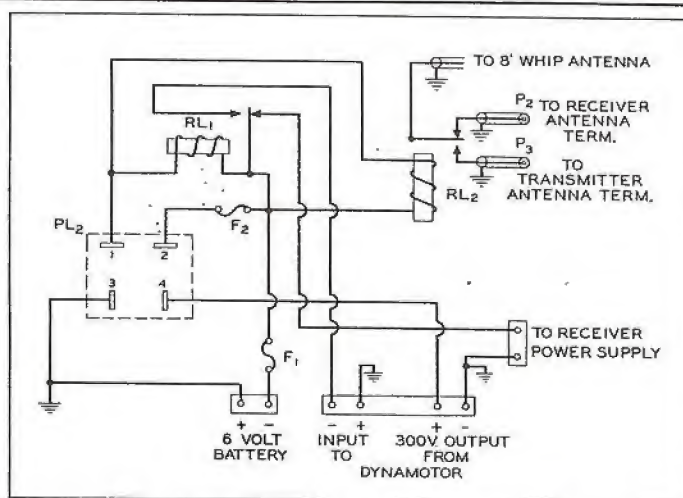
ohms, determined by the chart accompanying the transformer.

The 1000-ohm potentiometer which controls the microphone current must be insulated from the chassis because this miniature style pot is obtainable only with the rotor grounded. The proper connection of C$_{11}$ should be determined before it is installed because its polarity must correspond to the polarity of the car battery. The connections shown in the schematic is for cars having the positive battery terminal grounded.

Checking The Modulator

It is a good idea to test the modulator thoroughly before mounting it in the chassis. The best check is to complete the wiring of the transmitter and operate it in the phone band with a temporary antenna. The 3 tubes in the modulator should draw approximately 48 ma at 300 volts. If ac is used for heater power during the test, use a 6-volt battery for energizing the microphone. Modulation can be checked on a scope by conventional methods or on a good phone monitor. The microphone used with this transmitter is a surplus T-17 single-button carbon unit. The bakelite face plate should be removed and 5 or 6 additional holes drilled in it. These additional air paths increase the output of the T-17 substantially, because its basic design is for close-talking service and low extraneous pickup.

The leads connected to S$_1$ are passed through the grommet in the lower shelf and then through the grommet in the back of the chassis. Then, the lower shelf is positioned diagonally in the chassis with the modulation transformer against the rf shelf and the left end of the shelf above R$_6$. Next, the modulator transformer is pushed down and the shelf fastened in position. T$_2$, C$_{11}$, and J$_2$ are then fastened in position.

The many enjoyable contacts this transmitter has provided, its handy compactness, and its excellent signal quality make it a very worthwhile spring project for a summer-vacation time of QSO's on 10 and 11.

Transmitter power supply and switching arrangement.

(1) Terman-Radio Engineers Handbook, Section 9-3, "Suppression of Harmonic Radiation".

PARTS LIST

C$_1$	0.00015 uf, 500 V, Aerovox #1468, Mica
C$_{2, 4, 6, 7, 8}$	0.001 uf, 500 V, Aerovox #1468, Mica
C$_5$	25 uuf, Variable, Millen #20025
C$_5$	50 uuf, Erie Ceramicon #V39J-139
C$_9$	50 uuf, Variable, Millen #19050
C$_{10}$	100 uuf, Variable, Hammarlund HF-100
C$_{11}$	50 uf, 6V, Electrolytic, Cornell Dubilier BBR 50-6
C$_{12}$	10 uf, 25V, Electrolytic, Cornell Dubilier BBR 10-25
C$_{13, 14}$	0.01 uf, 400V, Paper, Cornell Dubilier ZNW4S1
C$_{15}$	20 uf, 25V, Electrolytic, Cornell Dubilier BBR 20-25
J$_1$	Crystal socket, 0.487" spacing, Millen 33102
J$_2$	Closed-circuit Jack, Mallory #A-2
J$_3$	Coax Connector, Chassis Type, Amphenol 83-1R
J$_4$	Microphone Jack, 3 circuit, Mallory #SCA-2B
L$_{1, 2}$	10 turns, ¾" Dia., 1¼" Long, B&W #3010
PL$_1$	4-contact male plug, Jones #P-404-CCT
PL$_2$	4-contact female socket, Jones #S-404-CCT
RFC$_1$	1.8 uh, RF Choke, Ohmite #Z-144
RFC$_2$	21. uh, RF Choke, Ohmite #Z-28
RL$_1$	6-V, SPDT Relay, 15A Contacts
RL$_2$	6-V, SPDT Antenna Relay
R$_{1, 8, 9}$	100,000 ohms, ½ W, Carbon, Ohmite Little Devil
R$_{2, 5}$	6,800 ohms, 2 W, Carbon, Ohmite Little Devil
R$_3$	20,000 ohms, 1 W, Carbon, Ohmite Little Devil
R$_4$	68 ohms, ½ W, Carbon, Ohmite Little Devil
R$_6$	1,000 ohms, Pot. Mallory CIMP
R$_7$	3,300 ohms, ½ W, Carbon, Ohmite Little Devil
R$_{10, 12}$	200,000 ohms, ½ W, Carbon, Ohmite Little Devil
R$_{11}$	15,000 ohms, ½ W, Carbon, Ohmite Little Devil
R$_{13}$	390 ohms, 2 W, Carbon, Ohmite Little Devil
R$_{14, 15}$	33,000 ohms, 1 W, Carbon, Ohmite Little Devil
S$_1$	DPST, Toggle Switch, C-H, #8360, with bat handle
S$_2$	Momentary Push Switch, Norm Closed, Centralab #1470
T$_1$	Microphone Transformer—Stancor A4706
T$_2$	Modulation Transformer—10 W, Thordarson T-21M52

BEHIND-THE-PANEL VIEW
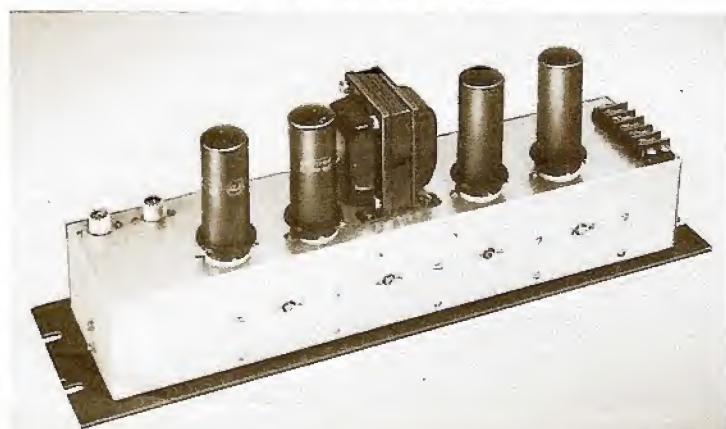
The frequency multiplier is mounted on a 3" x 4" x 17" aluminum chassis. Metal type 6L6 tubes are used in all stages for effective shielding. All components with the exception of the tubes and heater transformer are mounted inside the chassis.
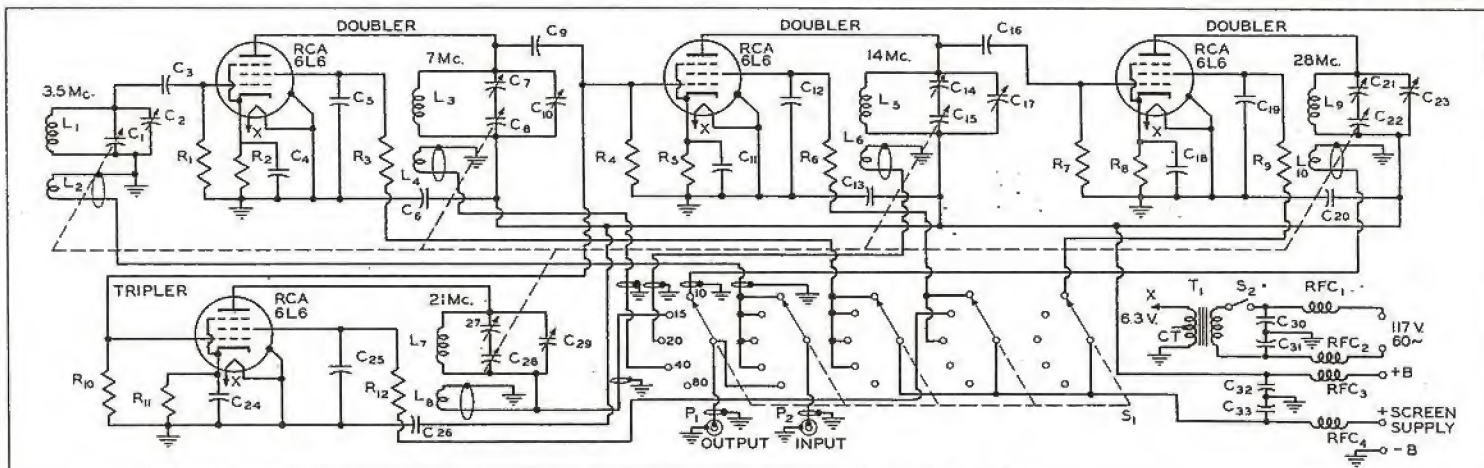
Schematic of the gang-tuned frequency multiplier.

FREQUENCY MULTIPLIER

Continued from Page 3, Column 1

of the VFO to 3.4 megacycles. When the multiplier band switch is in the 3.5-megacycles (80-meter) position, output power is available at the coaxial output connector (P_1). Next, turn the band switch to the 7-megacycle (40-meter) position and apply heater voltage to the multiplier tubes. Connect a vacuum-tube voltmeter such as the VoltOhmyst* Electronic Meter WV-195-A to the grid terminal of the first (7-megacycle) doubler stage. Before the plate voltage is applied, set the ganged tuning capacitors for maximum capacitance and adjust the parallel padding capacitor C_2 so that the input tank circuit is resonant. Resonance is indicated by maximum meter reading. If a low-range milliammeter is used, it should be connected in series with the grid resistor on the ground side. The excitation from the VFO should be increased until the voltmeter reads approximately 100 volts. If a milliammeter is used, the current should be approximately 3 ma. Now, turn the ganged tuning capacitors to the position of minimum capacitance and then reset the VFO frequency for maximum grid voltage. The frequency of the VFO should be slightly above 3.75 megacycles.

In the alignment of all stages, the meter should be placed either across the grid resistor of the stage following the one being aligned or else across the cathode resistor of the stage being aligned. To adjust the 7-megacycle doubler stage, leave the VFO at 3.75 megacycles and the ganged tuning capacitor at minimum capacitance, and apply voltage to the plates and screens. As soon as this voltage is applied, adjust the parallel padding capacitor C_{10} for resonance without delay. It is necessary to make this adjustment as quickly as possible because the out-of-resonance plate current may be excessive and damage the tube. The cathode current is approximately 25 ma; the cathode voltage as measured with the VoltOhmyst Electronic Meter is approximately 14 volts.

To complete the adjustment of the 7-megacycle doubler stage, tune the VFO to 3.4 megacycles and set the ganged tuning capacitor for maximum capacitance. Then, adjust the series padding capacitor (C_7) for maximum voltage across the grid resistor (R_4) of the 14-megacycle doubler stage. Return the VFO to 3.75 megacycles and adjust the parallel padding capacitor C_{17} to restore resonance. Only a slight change should be necessary.

All the other multiplier stages are aligned in exactly the same manner. The cathode current of the stage being used to excite the driver or final may be increased to as much as 60 or 70 ma. Cathode currents of all other stages will run approximately 25 ma per stage. For direct excitation of a final 813 power amplifier, a cathode current of 50 ma for the driving stage was found to be more than sufficient.

†"Self-contained VFO Designed for Stability on All Bands", by Andrew Rau, Jr., W3KBZ, (Ham Tips, Jan. Feb. 1949)
*Registered Trade Mark, U.S. Pat. Office

INTERIOR VIEW OF MULTIPLIER
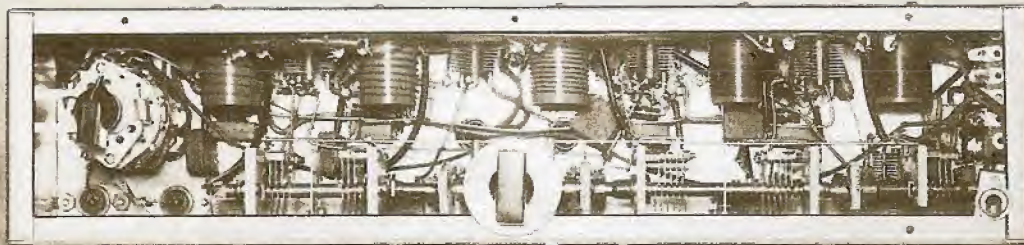
Well planned design of the frequency multiplier reveals simplicity of construction and the compact manner in which wiring and components are placed. The tuning control for the ganged tuning capacitors is brought out to the front panel by a right-angle drive shaft, shown in center of photo.

PARTS LIST

C_1	25 uuf, variable, Cardwell ZR-25-AS
C_2	100 uuf, variable (APC-100)
C_3	47 uuf, 500 V, mica
C_4, C_{11}, C_{18}	
C_{24}	.01 uf, 300 V, mica
C_5, C_{12}, C_{19}	0.006 uf, 500 V, mica
C_{25}	
C_6, C_{13}, C_{20}	
C_{26}, C_{30}, C_{31},	0.003 uf, 500 V, mica
C_{32}, C_{33}	
C_7	75 uuf, variable (APC-75)
C_8, C_{15}	35 uuf, variable, one section of Cardwell ER-35-AD
C_9	22 uuf, 500 V, mica
C_{10}, C_{14}, C_{21}	
C_{27}	50 uuf, variable (APC-50)
C_{16}	15 uuf, 500 V, mica
C_{17}, C_{23}, C_{29}	25 uuf, variable (APC-25)
C_{22}, C_{28}	25 uuf, variable, one section of Cardwell ER-25-AD
R_1, R_4, R_7 R_{10}	33,000 ohms, 1 watt, carbon
R_2, R_5, R_8 R_{11}	560 ohms, 1 watt, carbon
R_3, R_6, R_9,	
R_{12}	15,000 ohms, 2 watts, carbon
S_1	6 pole, 3 wafer, 6 position switch
S_2	SPST, 3 amp toggle switch
T_1	Heater transformer, 4.0 amps at 6.3 V
P_1, P_2	Coax male chassis connectors
RFC_1, RFC_2,	#24 Enamelled wire, wound on RFC_3, RFC_4 100,000 ohms, 2 watts, carbon resistor
L_1	35 turns #22e, wound 1" on National XR-2 form
L_3	21 turns #20e, wound 1" on National XR-2 form
L_5	13 turns #20e, wound 1" on National XR-2 form
L_7	8 turns #20e, wound 1" on National XR-2 form
L_9	6 turns #20e, wound 1" on National XR-2 form
L_2, L_4, L_6,	2 turns #18e, wound close to
L_8, L_{10}	cold end of tank coils

A SIMPLIFIED PROCEDURE FOR DESIGNING AUDIO MODULATORS

RCA WV-65A BATTERY VOLTOHMYST*

This popular instrument is particularly suited for a wide number of Amateur circuit applications. It can be used for accurate measurements of ac and dc voltage, for dc current, and for resistance. As a working tool, it belongs in every Ham Shack.

* Reg. Trade Mark, U. S. Pat. Off.

RCA VOLTOHMYST* ELECTRONIC METER IS HIGHLY VERSATILE IN HAM SHACK

By A. M. SEYBOLD, W2RYI
RCA Tube Department

Several million man-hours of work are spent each year by radio amateurs in building and repairing ham rigs. Part of that time is consumed in a sort of happy leisure, with the old soldering iron filling the shack with the pleasant odor of hot rosin flux. Likewise, some of those hours are burned away in the white heat of trying to finish a gimmick for testing a new idea or trying to get the rig back on the air to meet a sked or hit the zero hour for a contest. But, no matter what the project on hand may be, or whether your bench is in the cellar between the laundry tubs and the furnace, or "upstairs" with sound-proofed walls and carpeted floors, work-shop activity is a mighty important part of amateur radio.

Your tools for that work determine how pleasantly the time at the bench can be spent. Actually, minor miracles can be performed with a screw-driver, pliers, a hand drill, a file, and an old soldering iron. If your mechanical equipment fills the bill for the jobs you have on hand, how about the electrical end of the business?

The end product of your efforts is electronic equipment. If you have a tool that can get down into

*Reg. Trade Mark, U. S. Pat. Off.

the circuit you're working on and give the right dope on what's going on, you're going to end up with a rig that does what it's supposed to when it's supposed to. If you have one electrical tool that is capable of working in a variety of circuits, that tool belongs in the important category represented by screw-drivers and pliers, and it belongs on your bench in a position just as accessible. I have been using an

MODULATOR DESIGN MADE FLEXIBLE BY APPLICATION OF BASIC FORMULAS

By A. G. NEKUT, W3LIL
RCA Tube Department

In most amateur applications the problem of choosing a suitable audio modulator circuit is affected at the start by certain fixed conditions in the ham shack. Usually, for example, the modulator plate-supply voltage is fixed by the power supplies available. Often the modulation transformer available has an "impedance" rating that may not fit the value of plate-to-plate load resistance published under the typical operating conditions for the modulator tubes desired. It is the purpose of this article to present simplified design formulas which will aid in the design of a satisfactory modulator stage.

Because efficiency and economy of operation are usually of the utmost importance, this discussion will be limited to push-pull circuits using (1) beam power tubes, (2) power pentodes, or (3) power triodes operating in the positive grid region. Screen-grid type tubes may be operated under either high-bias class AB_1 or class AB_2 conditions; triode types operate, of course, under high-bias class AB_2 or class "B" conditions.

Let us start off with values of dc plate voltage (E_{bs}) and dc plate current (I_{bs}) of the fully loaded class "C" rf stage which is to be plate modulated. These values have been either computed [1] or obtained from published class C telephony operating conditions for the desired tube type.

The average audio power (W_a) in watts required to fully modulate this input power with sine-wave modulation is obtained as follows [2]:

Required average audio power $W_a =$

$$\frac{\text{dc plate voltage } E_{bs} \times \text{dc plate current } I_{bs}}{1.7} \qquad (1)$$

where E_{bs} is in volts and I_{bs} is in amperes.

The ac load resistance (R_s) in ohms presented to the modulation transformer secondary by the rf stage is given by

$$\text{AC load resistance } R_s = \frac{0.85 \, E_{bs}}{I_{bs}} \qquad (2)$$

Equations (1) and (2) allow for an efficiency factor chargeable to the modulation transformer and arbitrarily set at 85%. No specific allowance has been made for

IT'S SAFETY FACTOR THAT COUNTS

RCA power tubes have the extra safety factor required for plate-modulated service . . . ample reserve of cathode emission to satisfy modulation peaks . . . husky grid structures that permit ample drive without causing grid emission . . . high voltage insulation. Your RCA Tube Distributor has them in stock.
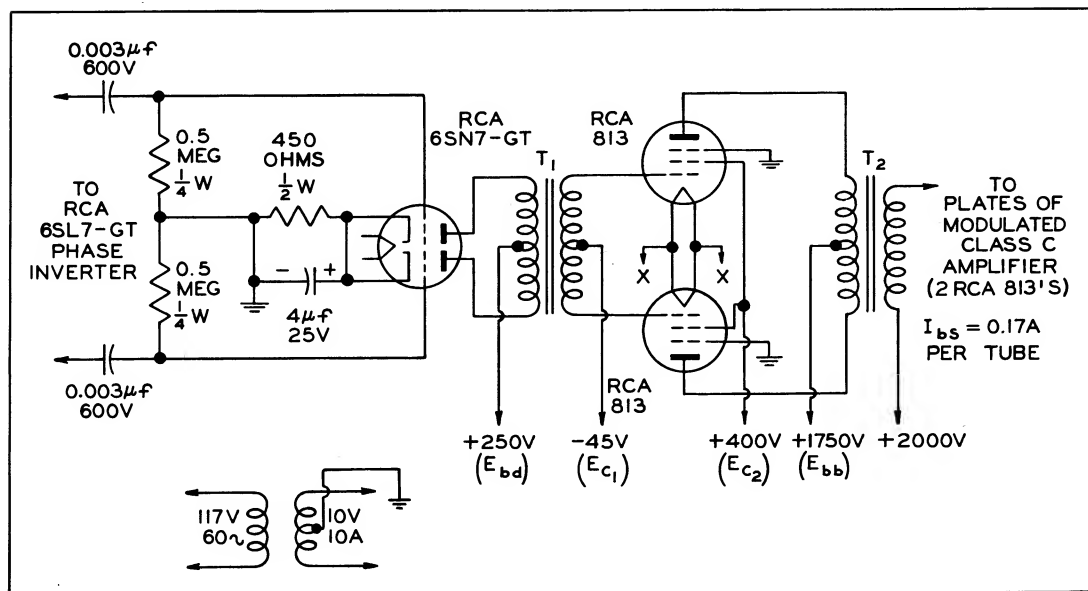
Figure 1. Modulator circuit designed from calculations given in text. It has not been built, and therefore, test data are not available.

Notes:
1) All power supplies returned to ground.
2) E_{c1} to be obtained from a source of good regulation (internal impedance equal to or less than 200 ohms).
3) The 250-volt supply may be obtained from a tap on bleeder for E_{c2} supply. Minimum bleeder current should be approximately 0.05 amperes.
4) T_1 = Driver Transformer—5-watt audio level—Total primary to ½ secondary turns ratio = 3.
5) T_2 = Modulation Transformer—400-watt audio level—one-half primary to total secondary turns ratio = 0.8.
6) E_{c2} and E_{bb} supplies should be adequately bypassed to ground for audio frequencies. Radio-frequency bypass capacitors at tube socket may be required under some conditions.

MODULATOR DESIGN

(Continued from Page 1, Column 4)

screen-modulation power which is usually negligible if a screen-voltage tap is available on the modulation transformer. If a dropping resistor is used to supply the screen with modulated voltage, the screen current per tube of the modulated stage should be added to I_{bs} before W_a and R_s are computed. It should be noted that satisfactory plate modulation of screen-grid tubes often results if the screen is fed from an unmodulated voltage source through an audio choke or a high resistance.

Design Procedure

Let us assume that the dc plate supply voltage for the modulator stage (E_{bb}) is fixed, and the design problem is to select suitable modulator tubes and a modulation transformer to meet the conditions imposed above. The following approximate relations will be used:

For E_{bb} in range from 400 to 750 volts	For E_{bb} in range from 1250 to 3500 volts	
$I_b = \dfrac{0.75\,W_a}{E_{bb}}$	$I_b = \dfrac{0.71\,W_a}{E_{bb}}$	(3)
$W_p = 0.25\,W_a$	$W_p = 0.21\,W_a$	(4)
$W_{in} = 0.75\,W_a$	$W_{in} = 0.71\,W_a$	(5)
$R_{pp} = \dfrac{1.3\,E_{bb}^2}{W_a}$	$R_{pp} = \dfrac{1.7\,E_{bb}^2}{W_a}$	(6)
$r = \sqrt{\dfrac{R_{pp}}{4R_s}}$		(7)

In the above relations, I_b is the max.-signal dc plate current *per tube* in amperes, W_p is the max.-signal plate dissipation *per tube* in watts, W_{in} is the max.-signal dc power input per tube in watts, and W_a is the audio power output for *two tubes* (push-pull stage) also in watts, all for sine-wave modulation.

R_{pp} is the plate-to-plate load resistance presented to the modulator tubes, and r is the turns ratio of the modulation transformer defined as

Modulation transformer turns ratio r =
$$\frac{\text{½ total number of primary turns}}{\text{number of secondary turns}} \quad (8)$$

It is assumed, of course, that the primary of the modulation transformer is center tapped and that the secondary feeds the class "C" rf stage to be plate modulated.

Modulator Tube Selection

Suitable modulator tubes (either screen-grid or triode types) may now be selected on the basis of maximum ratings[3] for either class AB_2 or class B audio service (or class C telegraphy ratings if audio ratings are not given) that are equal to or in excess of the values found from equations (3) to (6). It is evident from inspection of equations (6) and (7) that the selection of E_{bb}, R_s, and W_a automatically fixes the modulation transformer turns ratio, r. If a transformer having a different turns ratio is already available in the ham shack it will be necessary to change either one or all of the three quantities listed in order to make use of this transformer. If the turns ratio of the available modulation transformer is lower than the value given by equation (7), it is possible to operate the modulator tubes into a lower than optimum value of R_{pp}. However, unless E_{bb} is lowered also, this mode of operation is very inefficient and equations (3), (4), (5), and (6) are no longer valid. It should be noted that

Modulation transformer turns ratio r =
$$\sqrt{\frac{Z_p}{4Z_s}} \quad (7a)$$

where Z_p is the rated "impedance" of the total primary winding and Z_s is the rated "impedance" of the secondary winding.

After a suitable tube type has been selected, the published "Average Plate Characteristics" curves ("plate family") for this type should be used to determine suitable operating values. For screen-grid tubes a value of screen-grid voltage—and suppressor-grid voltage, if required — which can be readily obtained in the ham shack from a power source having good voltage regulation must be selected. A straight (load) line is drawn on the "plate family" curves connecting the point determined by "Plate Amperes" = 0 and "Plate Volts" = E_{bb} to the point determined by "Plate Volts" = 0 and "Plate Amperes" = I'_b where

$$I'_b = \frac{4E_{bb}}{R_{pp}} \quad (9)$$

The optimum value of grid-No. 1 bias may now be obtained from the relation

Optimum grid bias $E_{c1} = -\dfrac{(e_1 i_2 - e_2 i_1)}{(\ i_1 - i_2\ )}$ (10)

where the values of e_1 and e_2 are convenient intermediate values of grid-No. 1 voltage taken from the intersection of the load line with the bias curves, and i_1 and i_2 are the corresponding plate currents. In this equation it is assumed that the "e" and "i" points chosen lie on a linear portion of the tube's dynamic transfer characteristic and that the plate current of the non-working tube of the push-pull connection is zero. For this reason, the values of "e" and "i" chosen for equation (10) should lie well up on the load line but should not include points near the "knee" of the curve where some non-linearity may usually be expected. The plate dissipation under zero-signal conditions (W_{po}) may now be checked. Proceeding vertically upwards from E_{bb} on the "plate family" curves, read the value of plate current I_{bo} at the value of E_{c1} computed from equation (10). Then,

Zero-signal plate dissipation $W_{po} =$
$$E_{bb}\,I_{bo} \quad (11)$$

This value of W_{po} (zero-signal plate dissipation per tube) should not exceed approximately 1/3 to 1/2 of the maximum rated plate dissipation of the tube. If the value of E_{c1} found from equation (10) is not sufficiently negative to limit W_{po} to the desired value, it may be made more negative at the expense of only a slight increase in distortion at max.-signal levels; small-signal operation will produce larger amounts of distortion, but this mode of operation is generally of no consequence in modulator designs for voice communication. The peak of grid-No. 1 voltage (E_{gg}) in volts may be obtained from

Peak af grid-No. 1-to-grid-No. 1 voltage $E_{gg} = 2\,(e_{gm} - E_{c1})$ (12)

where e_{gm} is the instantaneous grid voltage obtained from the "plate family" curves at the intersection of the load line with the knee of the curve. If the tube chosen is a filamentary type and if the "Aver-
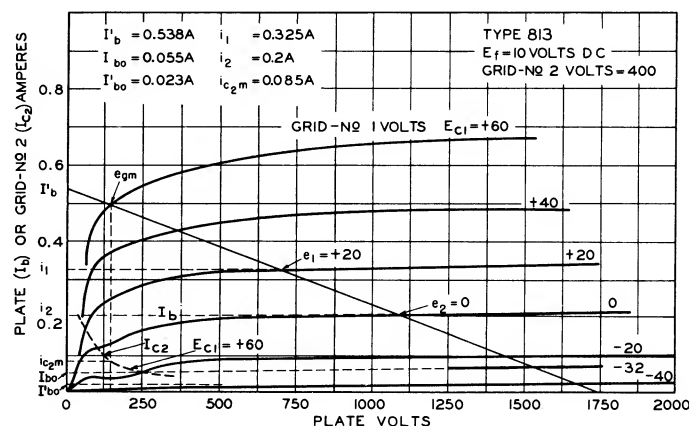
(Continued on Page 3, Column 1)

Figure 2. Average plate characteristics of the RCA-813.

MODULATOR DESIGN

(Continued from Page 2, Column 4)

age Plate Characteristics" curve is shown for a dc filament voltage (E_f), the grid bias value E_{c1} found from equation (10) should be made

more negative by $\dfrac{E_f}{2}$ volts when the

tube is used with an ac filament-voltage supply. This new value for E_{c1} should not be used in any of the calculations, however.

Driver Stage

A suitable driver stage and the turns ratio of the driver transformer may now be determined from the following considerations. If no current is drawn by grid No. 1 of the modulator tube, any conventional resistance-capacitance-coupled push-pull or phase-inverter voltage amplifier, comprising either triodes or pentodes, capable of supplying the required value of peak af grid-No. 1-to-grid-No. 1 voltage E_{gg} to the modulator circuit may be used.[4] If current is drawn by grid-No. 1 of the modulator tube, the following approximate relations are useful. For conventional low- and medium-mu triodes for the driver stage in push-pull class A or AB_1 connection

The driver transformer turns ratio $r_d =$

$$\frac{2.4 E_{bd}}{E_{gg}} \qquad (13)$$

and

Driver tube max. allowable plate resistance

$$R_{pm} = \frac{r_d E_{bd}}{6.7 i_{gm}} \qquad (14)$$

where r_d is the driver transformer turns ratio and is defined as

$$r_d = \frac{\text{total number of primary turns}}{\tfrac{1}{2}\text{ number of secondary turns}} \qquad (15)$$

E_{bd} is the plate supply voltage of the driver stage, i_{gm} is the instantaneous grid current drawn by grid No. 1 of the modulator tube in amperes at the value of e_{gm} used in equation (12), and R_{pm} is the maximum allowable driver-tube plate resistance in ohms. Tubes with values of R_p higher than indicated by equation (14) may be used but somewhat higher distortion will result. For single-ended class A driver circuits using conventional low- and medium-mu triodes

$$r_d = \frac{1.2 E_{bd}}{E_{gg}} \qquad (16)$$

Equations (14) and (15) also apply in this case. The power rating of the driver transformer should be adequate to handle at least the rated power output of the driver tube(s) in conventional class "A" (or AB_1 as the case may be), audio power-amplifier service.

The final value to be determined in computing tube operation is the screen-grid dissipation. Useful relations for approximating the value of average screen current (I_{c2}) in amperes and screen dissipation (W_{c2}) in watts at max.-signal levels are

Average screen current $I_{c2} = \dfrac{i_{c2m}}{4}$ (17)

Screen dissipation

$$W_{c2} = I_{c2} E_{c2} \qquad (18)$$

where i_{c2m} is the instantaneous value of screen current in amperes flowing when the instantaneous grid-No. 1 voltage is equal to e_{gm}, and E_{c2} is the dc screen voltage.

Modulation Transformer

Before proceeding with an example to illustrate the use of the relations given above, a brief discussion of modulation transformer "impedance" ratings may prove useful. Modulation transformers are usually rated in terms of primary

BATTERY VOLTOHMYST

RCA WV-65A Battery VoltOhmyst for that kind of work, and I'd like to nominate it for a permanent position in the screw-driver league. Let's have a look at some of the things this compact little battery-operated VoltOhmyst does for me.

DC Voltage Measurements

For measuring dc voltages, it's wonderful. The input resistance for all dc voltage scales (0-3 through 0-1000) is 11 megohms. This high value makes it possible to take voltage readings on even high-resistance circuits like avc lines and the control-grid circuits of a resistance-coupled audio amplifier. The insulated probe used for dc voltage measurements is shielded and contains a one-megohm isolating resistor which permits reading dc voltages at points such as the grid of a grid-leak self-biased oscillator where there is appreciable rf. The case of the meter is a good rf shield, so if the ground return is made to the outside of the box rather than through the pin jack normally used, dc voltage readings can be taken right next to a high-power plate tank with no error introduced by the rf field. Whenever it is necessary to make dc voltage measurements in the presence of heavy rf voltages, I pull out the "common" jack connector, and connect the ground return wire to the outside of the instrument case. I've used the Battery Volt-Ohmyst on my transmitters for 3.5, 14, 28, and 144 Mc, and have had no evidence of rf getting into the case at any of those frequencies.

By the way, the accessory RCA High-Voltage probe, WG-284, permits one to read up to 3000 volts dc full scale on the 30-volt position, 10,000 volts on the 100-volt position, and 30,000 volts on the 300-volt position. This probe gives an extremely high-resistance method of examining high dc voltages, and has come in mighty handy for work on my 14,000-volt kick-back television supply.

Some other places where this instrument has come in handy for reading voltages are as follows: bleeders and voltage dividers, grid-leaks, screen-dropping circuits, tube sockets, bias lines, and voltage regulator tube circuits.

DC Measurements

The dc current range of the Bat-

tery VoltOhmyst will handle most of the jobs a ham encounters. All scales, from the 0-3 milliampere to the 0-10 ampere settings, operate directly through the meter and do not require battery current. In the dc current-measuring position, the VoltOhmyst case is electrically isolated from the test leads. This feature permits current measurements to be made in high-voltage circuits without danger of shock from the meter case. For extra safety, the case can be grounded.

AC Voltage Measurements

The ac voltage scales on the Battery VoltOhmyst are also operated without the use of the internal battery supply. For these measurements also, the case is isolated electrically from the test leads. The sensitivity of the meter is 1000 ohms per volt. Measurements of power-transformer voltages, filament supplies, low-impedance audio circuits, and low-frequency rf potentials can readily be made.

For rf-voltage measurements and for low-frequency readings in high-impedance circuits, accessory RCA Crystal Probe, WG-263, is available. The probe connector goes right on the dc fitting, and the dc scales are used; they give readings of some values in the convenient RMS volts. The ac voltage sensitivity of the Battery VoltOhmyst is increased markedly by the use of this accessory, which makes it possible to do such things as track audio signals through resistance-coupled amplifiers and follow rf signals through the multiplier stages of transmitters.

Resistance Measurements

Because of the amplification obtained with the vacuum tube bridge circuit when the ohm scales are used, a wide range of resistance readings, from 0.1 ohm to 1000 megohms, is available. Consequently, the VoltOhmyst is an extremely versatile tool for checking resistor values when equipment is being built or repaired. Leakage paths in wiring can be checked, and leakage in transformers, sockets, capacitors, and other components can be found readily. If leakage paths or resistances above 1000 megohms are to be studied, use of the voltage probe and an external dc supply makes it possible to measure resistances in the order of tens-of-thousands of megohms.

Just recently my 10-meter transmitter went off the air during a QSO. The HV plate-supply fuse blew. I checked the plate line with the VoltOhmyst expecting to find a dead short, but the only evidence of a defect I could find was 50 megohms of leakage. I tracked this leakage with the meter to a lead-through bushing. There a fire-charred path had formed in the insulation. Of course I replaced the bushing and got the rig back on the air, but later I checked the defective part to see what had happened. Up to 400 volts, that leakage path stayed 50 megohms, but above 400 the charred path would arc through and produce a dead short. The VoltOhmyst had done a quick, sweet job in locating that screwball defect which would not have produced even the slightest deflection on an ordinary non-electronic volt-ohm-multiammeter.

Portability

Another good feature of the Battery VoltOhmyst is its portability. When you move the instrument around on the bench, or place it in a convenient spot at the transmitter or receiver, you don't have to juggle a power line or look for an extension cord, or reposition the meter to make measurements. The device is all set to go wherever it is put in either a vertical or horizontal position. For the boys with the mobile rigs and the field-day set-ups, the Battery VoltOhmyst comes right off the bench in the shack into the great outdoors and packs along as a sensitive, accurate, compact servicing tool that can be counted on in any emergency.

MODULATOR DESIGN

(Continued from Page 3, Column 2)

and secondary "impedance" and audio power (or more properly KVA) capability. The peak ac voltage (E_{pm}) that may be applied to ½ of the modulation transformer primary is

Peak ac voltage across primary $E_{pm} =$

$$\sqrt{\frac{W_t Z_{pm}}{2}} \qquad (19)$$

where Z_{pm} is the maximum impedance rating of the entire primary in ohms and W_t is the rated audio-power-handling capability of the transformer in watts. Similarly, the peak ac voltage (E_{sm}) permissible across the transformer secondary winding (equal to the dc plate voltage of the plate-modulated rf amplifier for 100% modulation) may be found from

Peak ac voltage across secondary $E_{sm} =$

$$\sqrt{2 W_t Z_{sm}} \qquad (20)$$

where Z_{sm} is the maximum secondary-impedance rating of the transformer. Of course, any voltage (and impedance) lower than these maximum rated values may be used. However, in order not to exceed the ac current ratings implied in the audio power and impedance ratings of a transformer having a fixed turns ratio, the power-handling capability of a transformer should be reduced approximately in accordance with the relation

$$W'_t = \frac{W_t R_s}{Z_{sm}} \qquad (21)$$

where R_s (as defined previously for equation (2)) is *less* than Z_{sm} and W'_t is the reduced audio-power-handling capability of the transformer. The dc current ratings of both primary and secondary windings are assumed to remain constant when the transformer is operated at other than rated impedance levels, although a reduction in primary dc current may allow some increase in ac current (allowing W'_t as given in equation (21) to be increased somewhat) and a reduction in secondary dc current may allow a slight increase in both E_{sm} (as given in equation (20)) and W'_t. For modulation transformers of the "multimatch" type it is assumed (unless information to the contrary is published by the manufacturer) that full power-handling capability has been preserved by

proper design for all rated impedance values.

Example

As an example, let us assume that the class "C" rf amplifier to be modulated is a push-pull circuit using 2 RCA-813's with a dc plate voltage (E_{bs}) of 2000 volts and a dc plate current (I_{bs}) of 0.17 amperes for each tube or 0.34 amperes for both. From equation (1), we obtain

Required average audio power $W_a =$

$$\frac{E_{bs} I_{bs}}{1.7} = \frac{(2000)\,0.34}{1.7} = 400 \text{ watts}$$

From equation (2), we obtain

AC load resistance $R_s =$

$$\frac{0.85 E_{bs}}{I_{bs}} = \frac{0.85\,(2000)}{0.340} = 5000 \text{ ohms}$$

If we assume that it is desired to operate the modulator from a 1750-volt supply, equations (3) to (5) yield

Max.-signal dc plate current per tube $I_b =$
$$\frac{0.71 W_a}{E_{bb}} = \frac{0.71\,(400)}{1750} = 0.162 \text{ amperes}$$

Max.-signal plate dissipation per tube $W_p =$
$$0.21 W_a = 0.21\,(400) = 82 \text{ watts}$$

Max.-signal dc power input per tube $W_{in} =$
$$0.71 W_a = 0.71\,(400) = 284 \text{ watts}$$

Inspection of the maximum ratings in the technical data[5] for power tubes shows that either the RCA-813 or the RCA-810 types will easily fulfill all requirements. If a 400-volt screen supply having good regulation is available, the 813 may be chosen to advantage, because this choice will ease the driver stage requirements somewhat in comparison to those required for the RCA-810. Equations (6) and (7) give us the required modulation-transformer impedance and turns ratio ratings.

Plate-to-plate load resistance $R_{pp} =$
$$\frac{1.7 E_{bb}^2}{W_a} = \frac{1.7\,(1750)^2}{400} = 13{,}000 \text{ ohms}$$

Turns ratio of modulation transformer $r =$
$$\sqrt{\frac{R_{pp}}{4R_s}} = \sqrt{\frac{13{,}000}{4\,(5000)}} = 0.806$$

The load line can now be drawn on the curve of "Average Plate Characteristics" shown in Fig. 2 after I'_b is obtained by means of equation (9) as follows

$$I'_b = \frac{4E_{bb}}{R_{pp}} = \frac{4\,(1750)}{13{,}000} = 0.538 \text{ amperes}$$
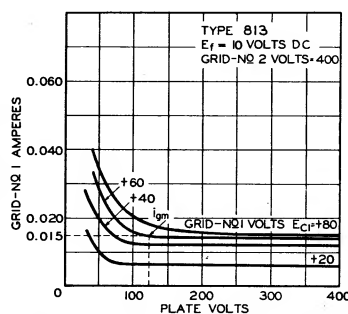
From equation (10) after points e_1

Figure 3. Grid characteristics of the RCA-813.

and e_2 have been selected, we obtained

Optimum grid bias $E_{c1} = -\left(\dfrac{e_1 i_2 - e_2 i_1}{i_1 - i_2}\right)$

$$= -\left(\frac{20\,(0.2) - 0\,(0.325)}{0.325 - 0.2}\right) = -\frac{4}{0.125} =$$

$$- 32 \text{ volts}$$

The value of I_{bo} at a grid bias of -32 volts is obtained from the family of average plate characteristics and then, from equation (11), we determine

Zero-signal plate dissipation $W_{po} =$
$$E_{bb} I_{bo} = (1750)\,(0.055) = 96 \text{ watts}$$

Because this dissipation value is in excess of ½ the maximum plate-dissipation rating; that is, greater than $\dfrac{125}{2}$ or 63 watts, a higher grid bias must be chosen. If a grid bias of -40 volts is used, the zero-signal plate dissipation is

$W_{po} = E_{bb} I_{bo} = (1750)\,(0.023) = 40$ watts which is a satisfactory value.

From equation (12), we can determine

Peak af grid-No. 1-to-grid-No. 1 voltage $E_{gg} = 2\,[e_{gm} - E_{c1}] =$
$$2\,[60 - (-40)] = 200 \text{ volts}$$

For ac filament operation, an

actual bias of -45 volts is required because the average plate characteristics were taken with a dc filament power supply of 10 volts.

If we assume that a push-pull driver stage having a plate supply voltage (E_{bd}) of 250 volts would be most desirable, then from equation (13) we obtain

Driver transformer turns ratio $r_d =$
$$\frac{2.4 E_{bd}}{E_{gg}} = \frac{2.4\,(250)}{200} = 3$$

From Fig. 3, at the value of instantaneous grid-No. 1 voltage obtained from the plate family curves at the intersection of the load line with the knee of the curve, $e_{gm} = 60$ volts. At a plate voltage corresponding to the intersection of the load line and the curve of $e_{gm} = 60$, the value of instantaneous grid-No. 1 current (i_{gm}) is 0.015 amperes.

Hence, from equation (14) the maximum allowable plate resistance of the driver tube (R_{pm}) is given by

$$R_{pm} = \frac{r_d E_{bd}}{6.7 i_{gm}} = \frac{3\,(250)}{6.7\,(0.015)} = 7460 \text{ ohms}$$

An RCA 6SN7-GT in push-pull class "A" connection will meet the requirements for a driver tube. From Fig. 2 the instantaneous screen current (i_{c2m}) is found to be 0.085 amperes.

From equations (17) and (18), we obtain

Average screen current $I_{c2} =$
$$\frac{i_{c2m}}{4} = \frac{0.085}{4} = 0.021 \text{ amperes}$$

Screen dissipation $W_{c2} =$
$$E_{c2} I_{c2} = 400\,(0.021) = 8.5 \text{ watts}$$

This value is well within the ratings for screen power input for the RCA 813. All the pertinent design information for the modulator is given in Table I. Fig. 1. is a typical circuit based on these values.

TABLE I
AUDIO MODULATOR USING 2 RCA-813's IN CLASS AB$_2$

Values are for 2 tubes	
DC Plate Voltage	1750 volts
DC Grid- No. 3 Voltage	0 volts
DC Grid- No. 2 Voltage	400 volts
DC Grid- No. 1 Voltage*	−45 volts
Peak AF Grid- No. 1 to Grid- No. 1 Voltage	200 volts
Zero-Signal DC Plate Current	0.046 amperes
Max.-Signal DC Plate Current	0.324 amperes
Max.-Signal DC Screen Current	0.042 amperes
Effective Load Resistance (Plate-to-plate)	13,000 ohms
Max.-Signal Power Output	400 watts
Output Transformer Turns Ratio, r	0.806
Driver Transformer Turns Ratio, r_d	3
Driver Tube	6SN7-GT (or equivalent)
* For AC filament operation	

FOOTNOTES

1. "Simplifying the Calculation of Transmitting Triode Performance" by E. E. Spitzer, "Ham Tips," Nov.-Dec. 1948.
2. Although it is true that considerably less average audio power than the value of W_a given above is required for voice modulation, the peak power capability of the modulator must be adequate if severe distortion at the voice peaks is to be avoided. It is necessary, therefore, to compute the modulator circuit constants for sine-wave signal conditions. Somewhat lower values of plate dissipation than those calculated later will result if voice modulation is used exclusively and this fact may therefore be considered in selecting suitable modulator tubes on the basis of their maximum plate dissipation rating (and, incidentally, in choosing the dc current rating of the modulator plate supply). It is well to remember, however, that if the modulator tubes are chosen with a plate dissipation rating that is only "just sufficient" for voice modulation, a sustained whistle into the "mike" or several seconds of rf, audio circuit, or acoustical feedback, will produce excessive plate dissipation and may result in tube failure.
3. See footnote 2.
4. See pages 196ff in RCA Receiving Tube Manual, RC-15.
5. RCA Tube Handbook HB-3; Headliners for Hams, HAM-103.

RCA ANNOUNCES NEW 811-A TRIODE AND HAM RATINGS

Here's tube value that gives you more than your money's worth. Power and performance — huskier construction, greater high-voltage insulation, and a plate structure with radiating fins are just a few of the features that make the new RCA 811-A one of the sweetest power triodes your money can buy. Intended for use as a class B af power amplifier and modulator, it is also well suited for class C telephony and telegraphy. In class B af service and in unmodulated class C service, the 811-A has a maximum plate dissipation of 65 watts (ICAS).

Because of its high perveance, the 811-A operates at high efficiency and with low driving power. For example, a pair of 811-A's in class B af service with a plate input of 470 watts (ICAS) requires a driving power at the tube of only 4.4 watts, and can modulate 100 per cent an rf amplifier having an input of 680 watts.

The RCA 811-A supersedes the 811 and can be used in the same socket without circuit changes. Economy is the keyword in initial cost and operation—Price to amateurs — only $4.05. It's available from local RCA Distributors.

IN YOUR NEXT ISSUE OF RCA HAM TIPS

Don't miss the next issue of RCA HAM TIPS due at your local RCA Distributor November First. In it you'll find a trim little mate for the "Tiny Tran" Mobile Transmitter in the form of a double-conversion, 8-tube, superhet receiver, completely self-contained except for the power supply and speaker. Built in the same small case as the "Tiny Tran", this compact receiver is sure to please the most exacting Ham. It operates on 10 and 11 meters. You'll want to build one like it for your car or shack. Ask your RCA Distributor to reserve your copy of RCA HAM TIPS for you —so you'll be sure to get all the important details.

A SOLID HANDFUL OF POWER

A pair of the new RCA 811-A's in AF or RF, AM or FM, can really deliver the goods. Priced at only $4.05 each, a pair offer you economy and dependability plus.

USING THE RCA-5763 FOR FREQUENCY MULTIPLICATION

By ROBERT M. COHEN, W2LHP
Application Engineer, RCA Tube Department

Amateurs will find many uses for the new miniature transmitting tube, RCA-5763, which operates very efficiently as a doubler, tripler, or quadrupler at frequencies up to 175 Mc. Although intended primarily for mobile service*, its outstanding performance makes it deserving of a place in fixed station equipment where flexible all-band operation is desired.

The basic principles of multiplier operation have been discussed in some detail in previous issues of HAM TIPS**, to say nothing of the reams of technical literature available in the handbooks and elsewhere, so it appears logical to limit our discussion to the particular operating conditions and circuits specifically applicable to the 5763. Fig. 1A shows the application of the 5763 as a frequency multiplier in the conventional manner. The accompanying photograph (Fig. 1B) shows the lead arrangement and location of parts and is indicative of the generally accepted methods for obtaining short leads and proper circuit bypassing—features necessary for good high-frequency performance.

* "TINY TRAN"—HAM TIPS, May-June, 1949
** "Understanding Frequency Doublers"—HAM TIPS, Jan.-Apr., 1947

Fig. 2 is a family of curves of useful power output versus operating frequency made with this circuit. The term "Useful Power Output" refers to the power which is delivered to the grid of the following tube or the transmission line; it is equal to the total tube power output less circuit and radiation losses. These data, presented in terms of useful power output, are of considerable value to the designer of a transmitter but are not necessarily indicative of tube efficiency, especially at high frequencies where the radiated energy and circuit losses consume a substantial part of the tube output. By way of illustration, the tank circuit power loss including tank circuit radiation is calculated approximately from the unloaded tank-circuit

FREQUENCY CHART AIDS IN COMPUTING HARMONIC RELATIONS

By 'PAT' PATTERSON, W2VBL
RCA Tube Department

How many times have you rummaged through debris on the operating table looking for a pencil to compute the frequency of a crystal or VFO dial?

To eliminate the guesswork, we've prepared the handy chart shown on page 2 and 3 of this issue of HAM TIPS. All frequencies are shown in megacycles and have been carried to three decimal places. In many instances, three-place computations do not come out even, hence these figures read low by the quantity of the decimal fraction beyond the third place. Where the figures for the low end of the band do not come out even, the frequencies shown have been extended to the high side of the incomplete decimal fraction in order to show a frequency that is inside the band.

Using the table is a simple matter. For example, a crystal reads 3.645 Mc. After locating this value in the 80 meter column and following it down to 10 meters, it's easy to see the resultant multiplied frequency is 29.160 Mc. Working in the opposite direction: to hit 28.680 Mc, follow the line up to the frequency range of the VFO or crystal, and it shows a setting of 3.585 Mc in the 80 meter band.

The 2, 6, and 11 meter bands do not directly relate to the lower bands, and, therefore, are shown in separate charts. The figures there show the same information, but are computed to several usable sub-multiples. In two meters, for example, if you are using an 8.055 Mc crystal, you must multiply 18 times to reach the band at 145.00 Mc. (Don't forget — the multiplication factors are not added, but multiplied. X 18 may be reached by tripling, tripling, and doubling, (3 x 3 x 2)). Conversely, to hit 146.5 Mc by multiplying 20 times, a crystal halfway between 7.3 and 7.35, or 7.325, is required.

You'll find good use for this chart. Tack it up on the shack wall near the rig and it will pay for its space in pencils and tempers saved.

FREQUENCY MULTIPLICATION AND DIVISION CHART

160M (See Note 1)

| 1.750 | 1.755 | 1.760 | 1.765 | 1.770 | 1.775 | 1.780 | 1.785 | 1.790 | 1.795 | 1.800 | 1.805 | 1.810 | 1.815 | 1.820 | 1.825 | 1.830 | 1.835 | 1.840 | 1.845 | 1.850 | 1.855 | 1.900 | 1.925 | 1.950 | 1.975 | 2.000 |

1.85625

80M

| 3.500 | 3.510 | 3.520 | 3.530 | 3.540 | 3.550 | 3.560 | 3.570 | 3.580 | 3.590 | 3.600 | 3.610 | 3.620 | 3.630 | 3.640 | 3.650 | 3.660 | 3.670 | 3.680 | 3.690 | 3.700 | 3.710 | 3.800 | 3.850 | 3.900 | 3.950 | 4.000 |

3.7125

40M

| 7.000 | 7.020 | 7.040 | 7.060 | 7.080 | 7.100 | 7.120 | 7.140 | 7.160 | 7.180 | 7.200 | 7.220 | 7.240 | 7.260 | 7.280 | 7.300 | 7.320 | 7.340 | 7.360 | 7.380 | 7.400 | 7.420 |

7.425

20M

| 14.000 | 14.040 | 14.080 | 14.120 | 14.160 | 14.200 | 14.240 | 14.280 | 14.320 | 14.360 | 14.400 | 14.440 | 14.480 | 14.520 | 14.560 | 14.600 | 14.640 | 14.680 | 14.720 | 14.760 | 14.800 | 14.840 |

14.850

14.300
14.250

10M

| 28.000 | 28.080 | 28.160 | 28.240 | 28.320 | 28.400 | 28.480 | 28.560 | 28.640 | 28.720 | 28.800 | 28.880 | 28.960 | 29.040 | 29.120 | 29.200 | 29.280 | 29.360 | 29.440 | 29.520 | 29.600 | 29.680 |

29.700

28.500　　29.000

KEY

▨ **A1**	▦ **NBFM**
■ **A3**	▒ **FM**

TYPES OF EMISSION

A0	———	Unmodulated Carrier
A1	———	CW
A2	———	Modulated CW
A3	———	Amplitude Mod.
A4	———	Facsimile
A5	———	Television

NBFM

FM or Carrier Shift Telegraphy

NOTE 1: Due to the variable status of the 160 meter band at this time, no effort has been made to define its limits. Consult the FCC regulations governing the local area before operating in this range.

2 METERS

÷	144.000	145.000	146.000	147.000	148.000
2	72.000	72.500	73.000	73.500	74.000
3	48.000	48.333	48.666	49.000	49.333
4	36.000	36.250	36.500	36.750	37.000
5	28.800	29.000	29.200	29.400	29.600
6	24.000	24.166	24.333	24.500	24.666
8	18.000	18.125	18.250	18.375	18.500
9	16.000	16.111	16.222	16.333	16.444
10	14.400	14.500	14.600	14.700	14.800
12	12.000	12.083	12.166	12.250	12.333
15	9.600	9.666	9.733	9.800	9.866
16	9.000	9.062	9.125	9.187	9.250
18	8.000	8.055	8.111	8.166	8.222
20	7.200	7.250	7.300	7.350	7.400

6 METERS

÷	50.000	50.500	51.000	51.500	52.000	52.500	53.000	53.500	54.000
2	25.000	25.250	25.500	25.750	26.000	26.250	26.500	26.750	27.000
3	16.667	16.833	17.000	17.166	17.333	17.500	17.666	17.833	18.000
4	12.500	12.625	12.750	12.875	13.000	13.125	13.250	13.375	13.500
5	10.000	10.100	10.200	10.300	10.400	10.500	10.600	10.700	10.800
6	8.334	8.416	8.500	8.583	8.666	8.750	8.833	8.916	9.000
8	6.250	6.312	6.375	6.437	6.500	6.562	6.625	6.687	6.750
9	5.556	5.611	5.666	5.722	5.777	5.833	5.888	5.944	6.000

11 METERS

÷	26.960	27.000	27.040	27.080	27.120	27.160	27.200	27.230
2	13.480	13.500	13.520	13.540	13.560	13.580	13.600	13.615
3	8.987	9.000	9.013	9.026	9.040	9.053	9.066	9.076
4	6.740	6.750	6.760	6.770	6.780	6.790	6.800	6.807
6	4.494	4.500	4.506	4.513	4.520	4.526	4.533	4.538

RCA　　RCA

FREQUENCY MULTIPLICATION

(Continued from Page 1)

parameters by means of the following relation:

$$\text{Total Tank Circuit Loss} = \frac{E^2 2\pi fC}{Q}$$

f = frequency in megacycles

Q = Q of unloaded tank circuit with tube out and circuit restored to resonance

E = RMS value of tank circuit voltage in volts with tank circuit unloaded

C = Total value of tank circuit capacitance including tube, wiring, etc. in microfarads

For the doubler circuit given in Fig. 1 when used in a typical compact mobile transmitter, the total tank circuit loss at 150 Mc is:
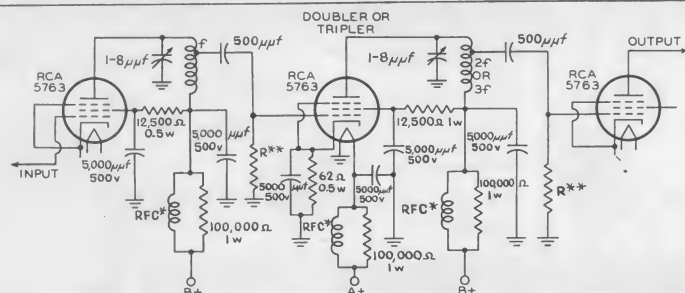
$$\frac{(150)^2 \times 6.28 \times 150 \times 15 \times 10^{-6}}{110}$$

= 2.86 watts

This value, approximately equal to the useful power output, is large but is typical of the normal condition in the 150-Mc region when "lumped circuits" are employed. The tank circuit Q of 110 is reasonably good and the total capacitance of 15 uuf is difficult to reduce.

Fig. 3 is a chart giving the recommended operating conditions for the multiplier circuit. Both doubler and tripler operating conditions are given, since the same circuit is used with a change in grid-No. 1 resistance. It is well to remember that when the tube is operated at lower B supply voltage than indicated, best multiplier operation occurs, in general, with high driving voltage, high developed bias, and with tank circuits having very low capacitance. In order to obtain maximum power output at high frequencies, the value of the grid-No. 2 resistor should be adjusted so that the full rated value of 250 volts is applied to grid No. 2.

The plate circuit efficiency of this tube is sufficiently good to allow application of full power input at frequencies up to 175 Mc. It is important to note that above 125 Mc, greater power gain is obtained when the tube is used as a doubler than as a straight-through neutralized amplifier because loading of the driving stage due to the input resistance of the 5763 is less severe at the lower frequency.

Because of its low value of output capacitance, two 5763's may be used to advantage in the "push-push" doubler circuit shown in Fig. 4. A single 5763 used as a tripler will provide more than adequate driving power, making a combination which is especially suitable for a low-power transmitter. Fig. 2 also shows a chart of measured power output as a function of operating frequency (solid lines) similar to that shown for the single multiplier (dotted lines).

Because the grid-No. 2 dissipation of this beam pentode will increase rapidly when the excitation is increased, especially with an unloaded amplifier, the maximum allowable grid No. 2 input of 2.0 watts must not be exceeded. Tubes can be quickly ruined if this rating is not adhered to.

Because of the high amplification factor of the 5763, a small cathode resistance of 62 ohms can furnish sufficient voltage to protect the tube in the event of temporary excitation failure and resultant loss in bias developed across the grid resistor. The cathode bias of 5.0 volts required for protection is sufficiently small to make the loss in dc plate voltage negligible.

Figure 2. *Useful power output of the RCA-5763 as a function of operating frequency in the circuit of Fig. 1A (dotted lines). The solid lines indicate the useful power output of RCA-5763's as a function of operating frequency in the push-push circuit of figure 3.*

BASE CONNECTIONS AND TYPICAL OPERATION:

RCA-5763

Figure 3.

	Doubler to 175 Mc	Tripler to 175 Mc	
DC Plate Voltage	300	300	volts
Grid No. 3	Tied to cathode at socket		
DC Grid-No. 2 Voltage	*	*	volts
DC Grid-No. 1 Voltage	−75	−100	volts
From a Grid-No. 1 resistor of	75000	100000	ohms
Peak RF Grid-No. 1 Voltage	95	120	volts
DC Plate Current	40	35	ma
DC Grid-No. 2 Current	4.0	5.0	ma
DC Grid-No. 1 Current (Approx.)	1.0	1.0	ma
Driving Power (Approx.)	0.6	0.6	watt
Power Output (Approx.) #	3.6	2.8	watts

* Obtained from plate supply voltage of 300 volts through a series resistor of 12500 ohms.

\#Useful power output is approximately 2.1 watts for doubler service and 1.3 watts for tripler service.

R** 75,000 Ω, 1W FOR DOUBLER; 100,000 Ω, 1W FOR TRIPLER
RFC* RF CHOKE, #24 ENAMEL-COVERED WIRE CLOSE WOUND ON RESISTORS

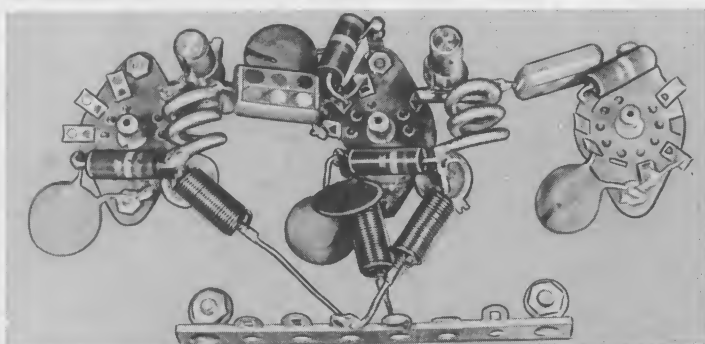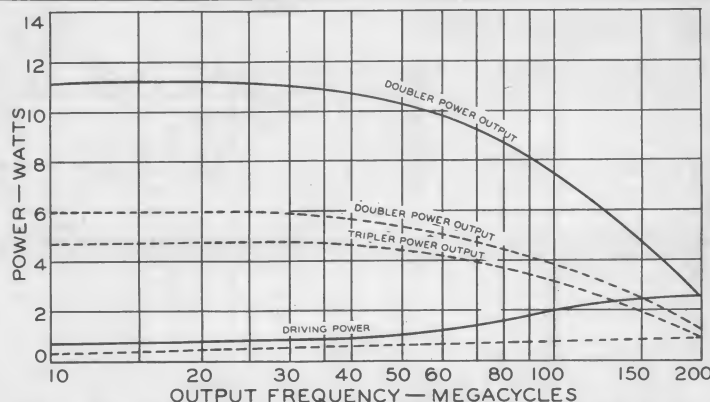Fig. 1A. *Frequency multiplier circuit diagram using the RCA-5763.*

Fig. 1B. *Photograph showing an actual model of a frequency multiplier constructed from the above diagram. Note that the placement of parts follows closely the position indicated in the diagram for the purpose of keeping leads as short as possible.*

* VALUES DEPENDENT ON OPERATING FREQUENCIES
RFC† RF CHOKE, #24 ENAMEL-COVERED WIRE CLOSE WOUND ON RESISTORS

Figure 4. *Circuit diagram of the Push-Push Doubler using a pair of RCA-5763's.*

NEW RCA SPEAKER IS ACCLAIMED BY HI-FI ENTHUSIASTS

RCA 15-inch Duo-Cone Speaker Gives Extra Listening Pleasure

A top-notch good family relations program is made possible at moderate cost by RCA's introduction of a high-fidelity speaker, the RCA-515S1 15" Duo-Cone. With it, any ham worth his call can build, for his family's enjoyment, a true high-fidelity reproduction system. Most radios, phonograph combinations, as well as TV sets and communications receivers, when fed through a high-quality speaker are a revelation in good listening.

The 515S1 provides the listener with dual-speaker response — full depth of bass and a clear, natural upper register. The clarity and quality of its output make the full range of a symphony orchestra literally come to life and provide a remarkable contrast to "communications quality." Best of all, the installation won't require more than an evening or two away from DX.

Utilizing the unique magnet structure and Duo-Cone arrangement developed by RCA, the 515S1 has two voice coils, each driving a section of the dual cone. Over the range of cross-over frequencies, which is centered at 2,000 cps, the two cone-sections vibrate as a single cone; thus, the speaker avoids the cross-over interference characteristics of usual high-low speaker combinations.

Two output transformers have been designed especially to operate

FOUR TUBE TYPE NUMBERS CHANGED

Here's a tip for future reference—mark it down on your tube reference list. Dual type designations are being dropped on these four tubes and they will henceforth carry only one type number.

Dual Numbers	New Number
0A3/VR75	0A3
0C3/VR105	0C3
0D3/VR150	0D3
6U5/6G5	6U5

HOLIDAY GREETINGS
Sincere wishes *for* good health much happiness *and* DX
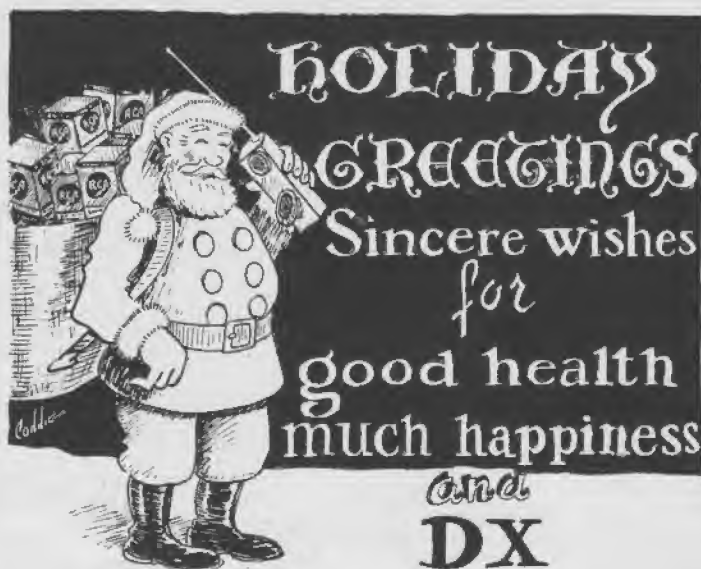
The Mobile Receiver Comes of Age - -
A DOUBLE CONVERSION TEN- AND ELEVEN-METER SUPERHET

By J. W. RICHARDT JR., W2WIY
Electronic Engineer

After the "Tiny-Tran" transmitter, which appeared in the May 1949 issue of HAM TIPS, the next logical project is a companion receiver to tune 10 and 11 meters. To match the performance capabilities of the Tiny-Tran rig, the "Tiny-Ceiver" was planned for "fixed-station" performance, hence the adoption of the double-conversion circuit.

The Double-Conversion receiver utilizes intermediate frequencies of 1560 and 455 kc. The tuned rf stage and the first mixer employ RCA-6BH6 pentodes and the local high-frequency oscillator uses an RCA-6C4 miniature triode. The rest of the tube lineup is as follows: RCA-6BE6 second mixer and low-frequency oscillator; RCA-6BJ6 455-kc if amplifier; RCA-6AL5 second detector, AVC, and automatic noise limiter; RCA-6AQ6 first audio; and RCA-6AK6 output.

The receiver uses a conventional AVC circuit and a self-adjusting series-type noise-limiting diode (ANL).

Layout Considerations

The cabinet of the receiver is a standard commercially available metal chassis 5 x 9½ x 3 inches with a perforated metal grille cut and

fitted as a cover. Any convenient type of mounting arrangement can be used. The rf head of the receiver is built on a small sub-chassis which is mounted to the left of the if strip. The other components of the receiver are built on a second sub-chassis. (See Fig. 5). The two sub-chassis units are drilled and fitted into the cabinet. When the mechanical work is completed, the units are removed for wiring. The front-panel layout and rear-terminal layout can be clearly seen in the photograph. Minor deviations in dimensions can be made.

The layout of the rf head of the receiver is shown in the top view of the finished assembly (Fig 5). The placement of all the parts as shown in the photographs should be closely followed.

W2IOP JOINS RCA ADVERTISING-SALES PROMOTION STAFF

To Take Active Part In RCA Amateur Activities

Larry LeKashman, W2IOP, formerly Editor of CQ, is now a member of the advertising and sales promotion staff of the RCA Tube Department.

W2IOP, a prominent DX man, contest operator, and ARRL National Sweepstakes Winner in 1949, will, among his other duties, act in an advisory capacity to the Editor of HAM TIPS. In joining RCA, he swells the RCA Tube Department's number of licensed amateurs to sixty-one.

Author of numerous technical and non-technical articles, W2IOP is also Editor of the DX Handbook and TVI Elimination Handbook. On the air since 1934, Larry LeKashman has been continuously active, with the exception of the war years, on 80, 40, 20, 10 and 2. Now operating C.W. and 'phone on all bands, his editorial and amateur experience is expected to further strengthen RCA's close relationships with amateurs.

Among the many activities of W2IOP are long-time appointments in the ARRL Communications Department, DXCC, WAZ, WAS, and almost all foreign DX awards, including the first Worked-All-Europe award made to any amateur.

TO FIT THE SMALLEST CAR OR SHACK

Fig. 1. Front view of the Tiny-Ceiver after final assembly. Don't let its size fool you, performance is better than "standard."

TINY-CEIVER

Continued from Page 1

Six holes have been drilled in the cabinet next to the rf head to facilitate alignment of the stages with the unit in the cabinet. These holes may be covered with spring-clip type plugs if desired.

Wiring

In wiring the rf, if, and audio sections, all the leads are kept as short and direct as possible. Since the if amplifier has very high gain, it is advisable to shield all of the 455-kc if transformer leads. The gain control, AVC and ANL on-off switches, and the other connectors should be permanently wired after the receiver has been tested and mounted in the cabinet.

Alignment

The alignment procedure is conventional, but is briefly outlined for guidance. The first step is to check all operating voltages. These should be within ± 20% of the values specified on the chart. After the voltages have been checked, connect a signal generator to the control grid (grid No. 3) of the 6BE6 mixer and align the last two if transformers at 455 kc with the AVC in the off position.

After these stages have been carefully adjusted, reset the signal generator to 1560 kc and adjust the low-frequency oscillator coil L6 so that it is either 455 kc above or below the signal from the generator. If the 8-uuf trimmer (C21) does not have enough range to facilitate this adjustment, the 62.5-uuf fixed capacitor (C19) will have to be replaced with one which will allow this adjustment to be made.

Next connect the signal generator to pin 7 of the first mixer tube, 6BH6, and align the first if transformer at 1560 kc. When the alignment of this transformer has been completed, connect the signal generator, set at 26.8 Mc., to pin 1 of the 6BH6 mixer. With the variable capacitor C10 set at full capacitance and the trimmer C12 at about the halfway position, adjust the slug of oscillator coil L5 so that the oscillator is 1560 kc below the generator. After this adjustment has been completed, connect the generator set at 26.8 Mc to the antenna terminals and adjust the rf and mixer slugs for maximum gain. Set the generator at 29 Mc and tune in this signal with the receiver tuning dial. At this point, the rf, mixer, and oscillator trimmers should be adjusted for tracking. It may be necessary to adjust the slugs and trimmers alternately to obtain a combination which will give the required bandwidth as well as proper tracking throughout the range of the receiver.

Power Supply Considerations

Power requirements for this receiver are 250 volts at 58 milliamperes for the plate and screens and 6.0 volts at 1.5 amperes for the heaters. A power switch is not indicated because the author's installation provides a control box on the dash board for controlling the receiver and transmitter simultaneously. This switch, however, can be added to the receiver if desired.

Most vibrator-type power supplies are filtered well enough so that no additional filtering is required. Should more be necessary, the filters shown in the sketch in Fig. 2 should be sufficient. The vacant space on top of the if chassis in front of the power connector was provided for this filter. In severe cases of interference, it may be necessary to enclose the filter components in a metal shield.

If a solid metal cover is used for the receiver, it is desirable to drill a number of holes in it, since even at the low power consumption of this receiver, its small size would make it run hot. If the receiver is operated from the same power supply as the Tiny-Tran, a dropping resistor of 860 ohms (10 watts) will be required. This resistor can be mounted either in the power supply or in the control box.

The sensitivity of the receiver is 1 microvolt for a power output of 0.050 watts into a 3.2-ohm load, or a gain of 118 db measured with AVC and ANL off. If the unit is constructed carefully and aligned properly, it should give many pleasant hours of mobile or home station operation.

TINY-CEIVER VOLTAGE CHART

Tube		Plate	Grid 2	Cathode
6BH6	RF Amp	250 v	150 v	1 v
6BH6	First Mixer	250 v	50 v	2 v
6C4	H.F. Osc.	80-120 v		
6BE6	2nd Mixer	235 v	100 v	
	L.F. Osc.			
6BJ6	I.F. Amp	250 v	125 v	1 v
6AQ6	1st Audio	50 v		
6AK6	2nd Audio	245 v	250 v	9 v

All voltages measured with a Vacuum Tube Voltmeter such as the RCA VoltOhmyst*.
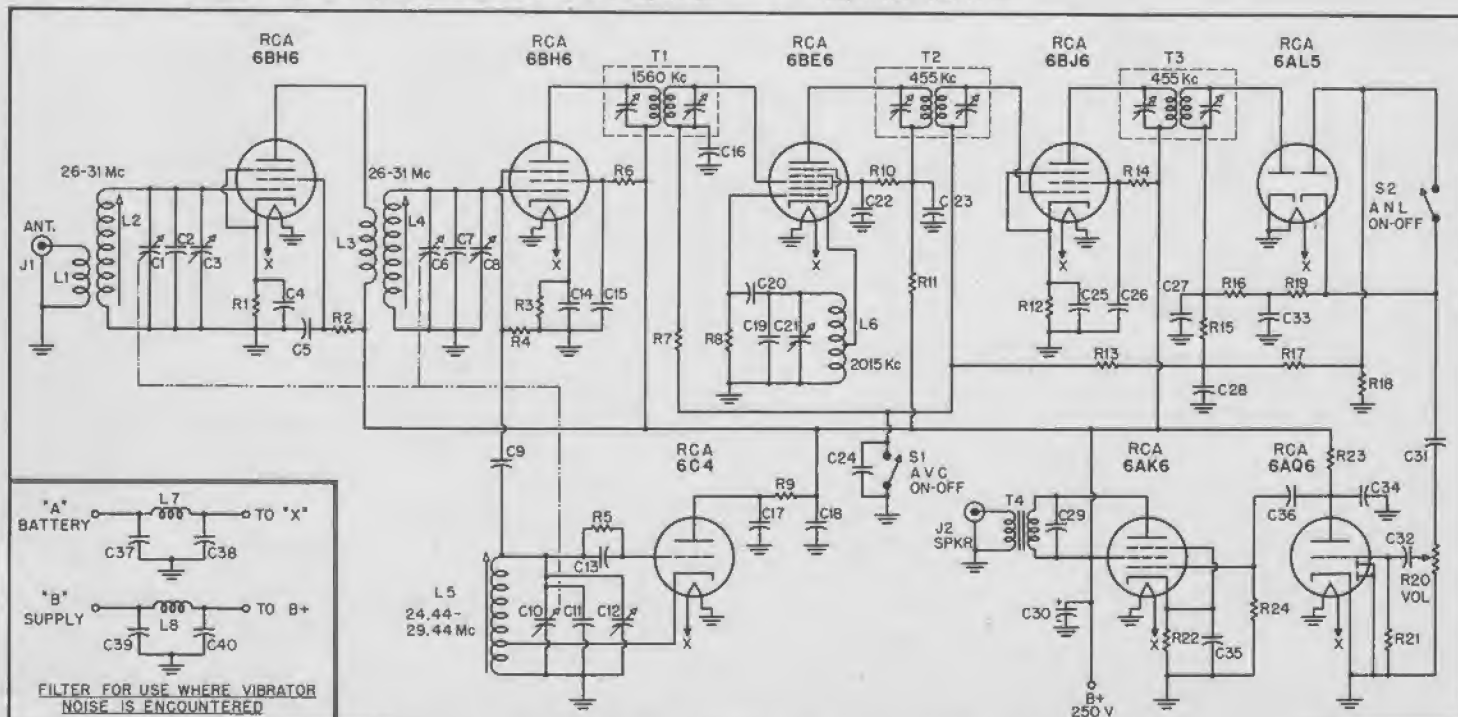
* Registered Trade Mark.

Fig. 2. Complete schematic of the Tiny-Ceiver 8 tube double-conversion 10-meter superhet.
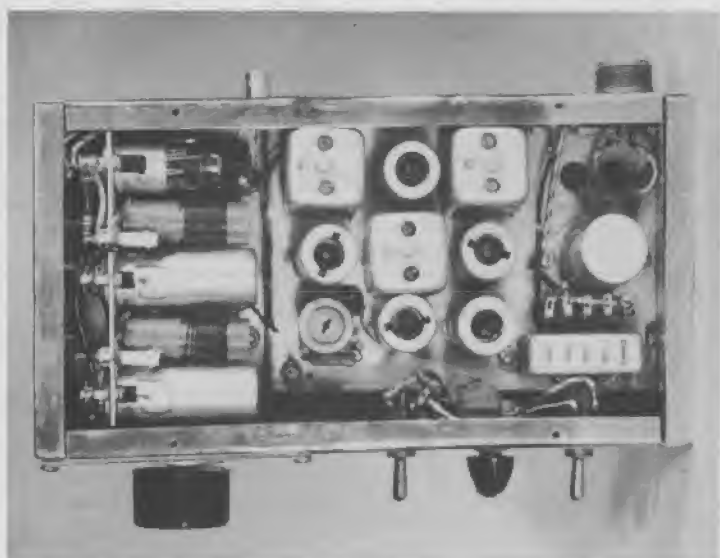
Fig. 3. Top view of the finished assembly showing placement of individual converter and if-af chassis within the compact case.

Fig. 4. Top view of the two units removed from the case shows placement of parts on both sub-chassis.

Fig. 5. A three-quarter view of both units reveals a maximum utilization of available space.

TINY-CEIVER PARTS LIST

C1, C6, C10	General Instrument Type 2801 3-gang variable, modified to have 2 rotor plates and 2 stator plates. (Note: Frame of this capacitor measures 1¾" x 1⅜" x 2⅞" long).	L8	2.5 mh RFC.
		S1, S2	SPST Switch.
		R1	100 ohms.
		R2, R4, R14, R15	47000 ohms.
C2, C7, C11	10 uuf silver mica El Menco CM 20-100.	R3, R11	1000 ohms.
		R5, R8, R9, R10	22000 ohms.
C3, C8, C12, C21	1-8 uuf variable tubular Erie 532.	R6	150000 ohms.
C4, C5, C17, C29	5000 uuf Centralab Hi-Kap DA 048-001A.	R7	100000 ohms.
		R12	82 ohms.
C9	10 uuf Erie Ceramicon Type K.	R13	2.2 megohms.
C13, C20, C27, C28, C34	180 uuf silver mica El Menco CM 20-101.	R16	1 megohm.
		R17, R18, R23	270000 ohms.
C14, C15, C16, C18, C22, C23, C25, C26, C31, C32, C36	0.01 uf Centralab Hi-Kap.	R19	820000 ohms.
		R20	500000-ohm potentiometer.
C19	62.5 uuf Erie Ceramicon Type L.	R21	10 megohms.
C24, C33	0.01 uf 400v paper. Sprague 68P8.	R22	560000 ohms.
		R24	470000 ohms.
C30	20 uf 450v (Part of Mallory FP332—2 10 uf 450-volt sections in parallel) See C35.	J1	Amphenol BNC 31-003.
		J2	Bud., JP-248.
C35	10 uf 25v (Part of Mallory FP332) See C30.	T1	1560-kc if transformer. — Miller Type 012W1.
C37	0.001 uf.	T2	455-kc if transformer. — Miller Type 012C1.
C38	0.25 uf 25v.	T3	455-kc if transformer. — Miller Type 012C4.
C39	0.001 uf.		
C40	8 uf 350v.	T4	Output transformer for matching impedance of 6-8 ohm coil to 10,000 ohm load.
L1	2 turns #20E close-wound over cold end of L2.		
L2, L4	9 turns #20E, spaced to occupy winding area of National XR-50 coil form.	Dial Assembly	National MCN.
		All capacitors are 400-volts unless otherwise specified.	
L3	5 turns #36DSC, interwound at cold end of L4.	*All resistors are ½ watt unless otherwise specified.*	
L5	Same as L2 plus tap at 3 turns from ground end.	*The make and type numbers of the above parts are the ones used in the original construction. Substitutions may be made if physical and electrical characteristics are similar.*	
L6	Oscillator coil — Miller 5481-C.		
L7	20 turns #14, ½" diameter-close-wound air core.		
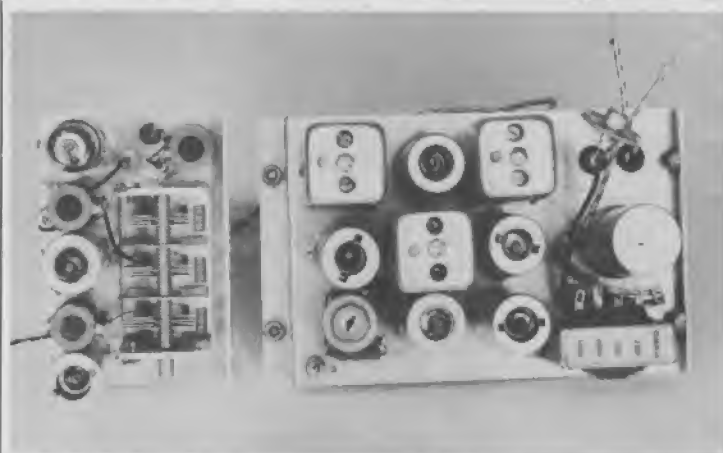
DUO-CONE SPEAKER

Continued from Page 1

with RCA-515S1. For operation from line-to-voice coil, RCA-213T1 output transformer is recommended. For operation from tube-to-voice coil, RCA-214T1 output transformer is recommended. These units are multi-tapped for several input impedances.

Be sure to see the RCA-515S1 Duo-Cone speaker at your local RCA distributor.

515S1 DATA

Power-Handling Capability	25 watts
Input Impedance (At 400 cps)	16 ohms
Diameter of Low-Frequency Voice Coil	2 inches
Diameter of High-Frequency Voice Coil	¾ inch
Magnet Weight	2 pounds
Speaker Weight	15 pounds
Frequency Response	40-12,000 cps
Speaker Resonance (With baffle)	40-55 cps
Total Angle of Directivity	60 degrees

The RCA-515S1 Duo-Cone Speaker.

ECHOES —

The Frequency Chart in the September-October issue of HAM TIPS contains an error. The third line of the 10-meter band indicated NBFM authorized from 29.0 to 29.7 Mc and FM from 28.5 to 29.0 Mc. It should have indicated NBFM authorized from 28.5 to 29.7 Mc and FM from 29.0 to 29.7 Mc.

COMING ATTRACTIONS . . .

The kind of keying that lets you look your neighbor in the eye, will be described in a timely article on "Electronic Keying Systems" by Mack Seybold, W2RYI, in the next issue of RCA Ham Tips. A well known author-amateur, Mack will be remembered for his outstanding work on low- and high-pass filters. Be sure to get the Jan.-Feb. Ham Tips from your local Distributor.

The Worked All States Log of _____

STATE	CAPITAL	CALL AREA	STATION WORKED	DATE	TIME	BAND	A₁/A₃	REPORT His	REPORT Mine	QSL Sent	QSL Rcd.
Alabama	Montgomery	4									
Arizona	Phoenix	7									
Arkansas	Little Rock	5									
California	Sacramento	6									
Colorado	Denver	Ø									
Connecticut	Hartford	1									
Delaware	Dover	3									
Florida	Tallahassee	4									
Georgia	Atlanta	4									
Idaho	Boise	7									
Illinois	Springfield	9									
Indiana	Indianapolis	9									
Iowa	Des Moines	Ø									
Kansas	Topeka	Ø									
Kentucky	Frankfort	4									
Louisiana	Baton Rouge	5									
Maine	Augusta	1									
Maryland	Annapolis	3									
Massachusetts	Boston	1									
Michigan	Lansing	8									
Minnesota	St. Paul	Ø									
Mississippi	Jackson	5									
Missouri	Jefferson City	Ø									
Montana	Helena	7									
Nebraska	Lincoln	Ø									
Nevada	Carson City	7									
New Hampshire	Concord	1									
New Jersey	Trenton	2									
New Mexico	Santa Fe	5									
New York	Albany	2									
North Carolina	Raleigh	4									
North Dakota	Bismark	Ø									
Ohio	Columbus	8									
Oklahoma	Oklahoma City	5									
Oregon	Salem	7									
Pennsylvania	Harrisburg	3									
Rhode Island	Providence	1									
South Carolina	Columbia	4									
South Dakota	Pierre	Ø									
Tennessee	Nashville	4									
Texas	Austin	5									
Utah	Salt Lake City	7									
Vermont	Montpelier	1									
Virginia	Richmond	4									
Washington	Olympia	7									
West Virginia	Charleston	8									
Wisconsin	Madison	9									
Wyoming	Cheyenne	7									

Here is your Worked-All-States log—ready and waiting to be filled in.

P. S. To log the 48 faster, and with better reports, equip your rig with RCA. For economy and dependability in transmitting and receiving tubes, insist on genuine RCA tubes in the familiar Red, Black, and White cartons. See your RCA Distributor today.

RCA BATTERIES ENGINEERED FOR RADIO SERVICES

RCA'S Complete Line Can Fill Variety of Ham-Shack Needs

Name your need — bias — test equipment—experimental circuits—field day or emergency gear—what have you—you can be sure there is an RCA Battery to fill the bill.

No amateur buys a part without carefully analyzing requirements versus capabilities, selecting the type and brand that does the best job. Batteries should be no exception to this buying habit. That's why you should know about RCA Batteries. RCA batteries are radio engineered and performance tested for extra service. The "mix" in RCA batteries is a special formula prepared to meet the particular load requirements of radio use. Its use is your assurance that RCA Batteries will stay fresh longer . . . have longer lasting power.

RCA Batteries are available *only* through radio parts distributors, another assurance that you will get the *right* battery at its *peak* of freshness. Insist on genuine RCA Batteries in the familiar red, black and white cartons. See your RCA Battery Distributor now.

WHAT'S NEW IN TUBES?

Type	Service	Sugg. List
1V2	Miniature high-voltage rectifier primarily for TV service	1.50
1X2	Miniature high-voltage rectifier primarily for TV service	2.65
6AS6	Miniature sharp-cutoff pentode with two grid-control electrodes	3.65
6AU5GT	Beam power amplifier for TV horizontal deflection	2.65
6AX5GT	Full - wave, high - vacuum rectifier with 6.3 v heater	1.35
6BQ6GT	Beam power amplifier for TV horizontal deflection	3.20
6CB6	Miniature high-grain pentode amplifier for TV	2.00
6CD6G	Beam power amplifier for TV horizontal deflection	6.00
6S4	Miniature medium - mu triode amplifier for TV vertical deflection	1.65
16GP4	Short 16" metal kinescope	60.00

HAM DISPLAY GREETS RCA VISITORS

The many visitors to the RCA Home Office during January were greeted by this display. Set up, ready for operation, it gave hundreds of people their first glimpse of a complete amateur radio station. QSL cards displayed were those of some of the many RCA Tube Department employees who are active ham operators. (I have to use the side entrance now—the receptionist still has a sore jaw from answering questions.—Ed.)

ELECTRONIC KEYING SYSTEMS

By MACK SEYBOLD, W2RYI
RCA Tube Department, Harrison, N. J.

Amateurs have been using electron tubes in keying circuits for the past twenty years. As a matter of fact, it was almost that far back when I operated cw on 80-meters with a pair of UX245's in parallel, to key the cathode circuit of an old 210. My recollection of that rig, even though it was a hay-wire bread-board dust-catcher, is very pleasant, and I never did get any key-click complaints from the nearby broadcast listeners or local hams.

Just to get an idea of where that keying circuit had come from, I recently thumbed back through the years of radio journals in my shack. To my amazement, I found dozens of keying circuits for the betterment of ham's estate.

Keying Filters

Among the more complete articles on the subject, there was one by the late Ross Hull. This carefully prepared resume in February, 1929, *QST*, covered all of the major systems in use up to that time. Even today, I'll bet that more than half of the boys on the air are using keying systems that were described in Hull's article. The main components used are chokes and capacitors. In addition to eliminating the sparks at the key contacts, proper utilization of the components in the keyed stage or in the feed lines to that stage minimizes the production of transients in the radiated signal when the key contacts make and break. A typical filter for cathode keying is shown in *Fig. 1*.

Sometimes the old choke and capacitor methods really do accomplish the desired results. But the

A SIMPLE CODE-PRACTICE UNIT FOR THE NOVICE

By KEN BUCKLIN, W2CDP
RCA Tube Department

Practice with a soldering iron is as important to the newcomer entering amateur radio as learning the code. The code practice oscillator described helps to accomplish both purposes. It is essential to prepare for the inevitable code test and to develop a good fist; it serves as a practical experiment for the novice; and after the new call letters have been issued, the parts can be put to other useful purposes.

"MEET THE GANG"

(First in a series of thumb-nail sketches introducing RCA Tube Department amateurs who contribute to Ham Tips. We hope you enjoy "Meeting The Gang.")

MACK SEYBOLD, W2RYI
ex-W8GGN, W3CQX

Age—35
Employed in—Chemical & Physical Lab, RCA Tube Department, Harrison, N. J.
Home QTH — 14 Gerdes Avenue, West Orange, N. J.
Graduate of—Lehigh University
Active on—2, 10, 20, and 75-meter Phone and cw.
Rig—300 Watts to RCA 813
XYL—Lois
Harmonic—Susy, Age 4½
Articles—Plate Traps—Low-Pass Filters *(QST)*
TVI Shielding—TVI-Proof Rig *(CQ)*
Class-B 807 Modulator and many others (Ham Tips)
Other Hobbies—Photography, Fishing, Boats

KEYING SYSTEMS

Continued from Page 1

tinkering required to clean up a thump or click condition with those systems, and their unreliability under varying conditions, are probably the fundamental causes for all of the additional work that has been done on keying circuits in subsequent years.

Early Electronic Methods

The first complete references that I could find in which vacuum tubes were used to make and break the circuit in the cathode lead of an
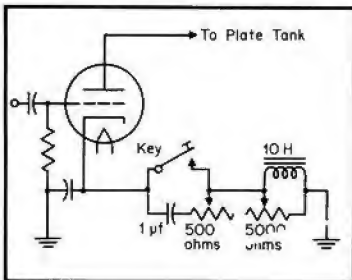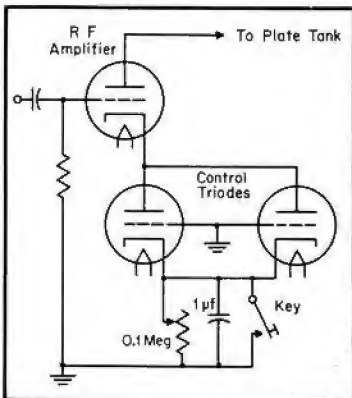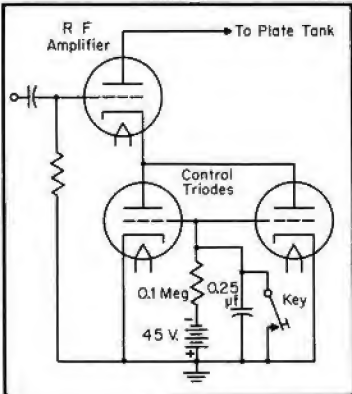

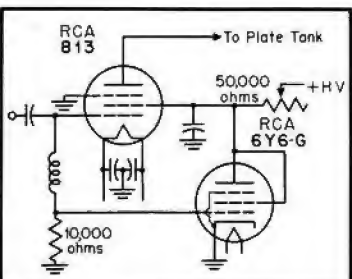Figure 1

Figure 2A

Figure 2B

Figure 3

amplifier were in *QST* for August, 1931. These references were, evidently, the source information for my earliest venture into electronic key-click control. One circuit is shown in *Fig. 2A*, and the *QST* article attributes the original idea to F. B. Kennell of RCA Communications. The immediate proponent of the system, W. H. Hannah, W2US, had remarkable success with the device in his amateur rig.

The same issue showed the circuit *(Fig. 2B)* of C. W. Carter, W3AGT, for another electronic key-click control which was the basis for many series-controlled systems which were to follow.

Screen-Grid Transmitting Tubes

During the first few years after power pentodes and tetrodes became available for amateur use, the same general methods which previously had been used for keying triodes were employed. Some of the boys did utilize the screen grid as a keying control element by putting a key or a relay in series with the screen lead, but this method still required the use of key-click filters.

The beginnings of vacuum-tube control of pentode-screen keying seem to have occurred in 1941. In the December *Radio* for that year, W. W. Smith, W6BCX, described "A Substitute for Safety Bias" which utilized a triode shunting the screen of an output tube. Later, F. T. Smith, W1FTX, built a transmitter (Feb. 1947 *QST*) in which a 6Y6-G, triode connected, controlled the screen of an 813. In these screen-shunting systems, an earlier stage is keyed, and the bias developed across the grid-leak of the final amplifier is the voltage which triggers the control tube. A diagram of the W1FTX final is shown in *Fig. 3*.

VR-Tube Keying

My solution to the problem of key-click control has been arrived at from a somewhat different approach, in that voltage-regulator tubes are used. The characteristics of the VR tubes are suited remarkably well for this application and the maximum ratings established for them are not exceeded in this new circuit.
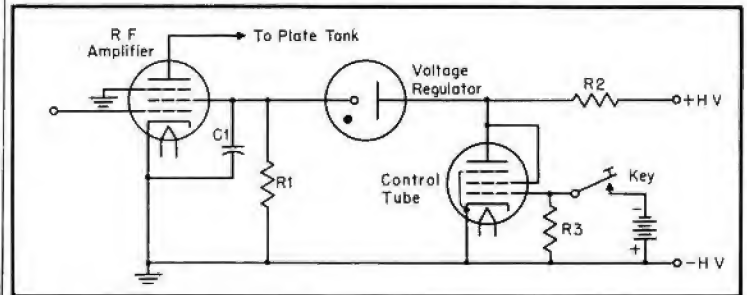
The gaseous atmosphere within a VR tube limits the tube to two major operating states — conducting, and non-conducting. In the conducting state, the current-carrying medium is ionized gas, and the voltage drop between anode and cathode is constant throughout a range of current flow from 5 to 40 milliamperes. In the non-conducting state, when the voltage applied between the anode and cathode falls below the ionizing potential of the gas, the tube virtually is an open circuit. For the 0A3, the voltage required for tube operation is 75 volts. For the 0C3 and the 0D3 it is approximately 105 and 150 volts, respectively. For the miniature types 0A2 and 0B2 it is approximately 150 and 108 volts, respectively.

When one of these tubes, say the 0C3, is placed in the screen supply lead of a pentode or tetrode, the tube will do one of two things: it will conduct or it won't. That, of course, is just what a mechanical key will do. In opposition to the key, however, there are no mechanical components to arc and spark when the circuit opens and closes. In addition, the ionizing and de-ionizing time of the

Figure 4

gas within the VR tube causes an infinitesimal time delay which smooths the leading and lagging edges of a keyed character.

Operation

The VR tube in a keying circuit is an effective non-mechanical keying gap. Since the tube needs no filament supply, it can be placed at any convenient point in the screen supply line. The VR tube is controlled by an auxiliary vacuum tube which determines the "on" or "off" conditions. This control tube is activated by applying the correct potential to its grid No. 1 and, since the grid No. 1 is operated at a negative potential, very little current flows in the actual key circuit. Figure 4 shows the basic components of the system.

When the key is down, the bias voltage applied to the control tube prevents it from conducting and the VR tube and the rf amplifier conduct current through R2. The supply voltage, minus the drops across R2 and the VR tube, is the effective screen-grid potential applied to the rf amplifier and permits normal key-down operation. When the key is up, the bias on the control tube drops to zero, making it conduct and, as a result, the voltage drop across it becomes lower than the required ionizing potential for the VR tube. The VR tube, therefore, stops conducting, the supply voltage is com-

Figure 6

Figure 5

pletely removed from the screen-grid of the rf amplifier, and the transmitter goes off the air.

This procedure can be repeated as often as desired, as in cw work; the rapidity of keying is limited only by the ionizing and de-ionizing characteristics of the VR tube. In the circuit of *Fig. 4*, the resistors R_1 and R_3 are high in value, and are present merely to maintain each grid at a potential near zero when keying potentials are removed. C_1 is a conventional rf by-pass capacitor.

Transmitter Circuits

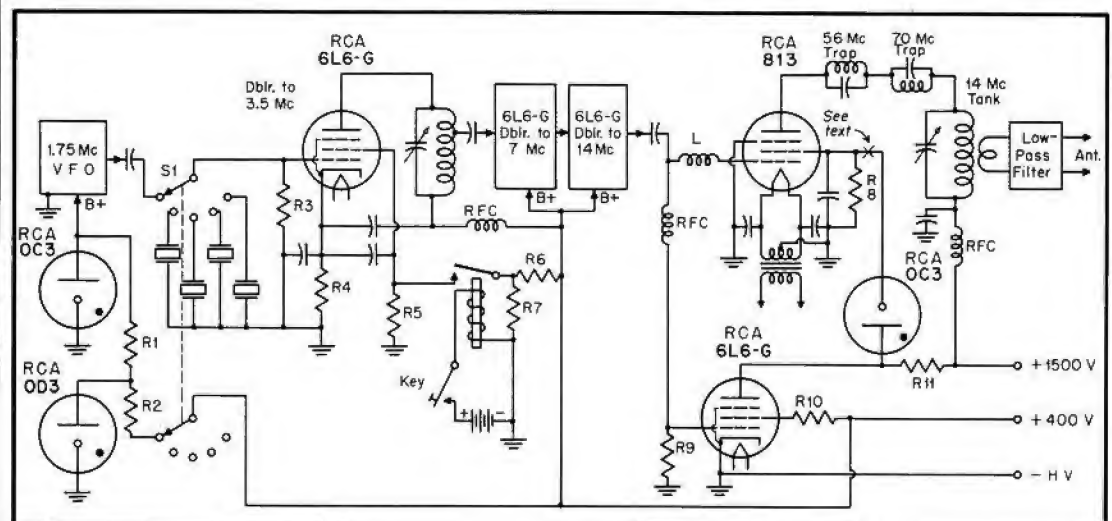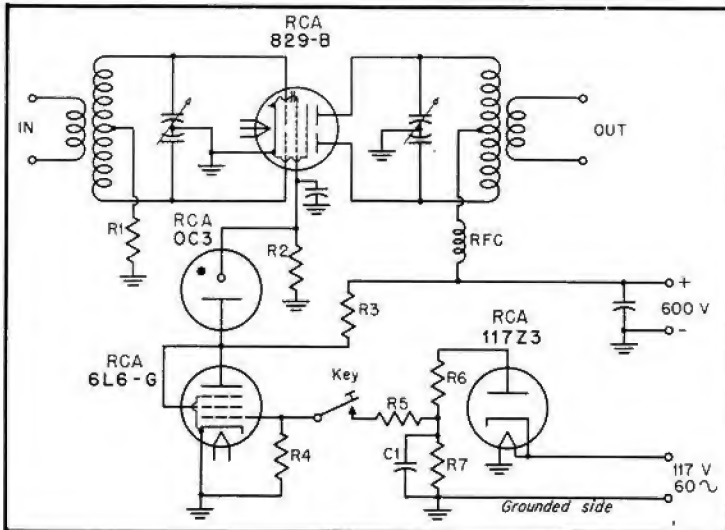A practical application of the system is shown in *Fig. 5*. Here an 829-B final is keyed with an 0C3 controlled by a 6L6-G. Cutoff bias for the 6L6-G is obtained from a 117Z3 as shown, or it can be taken from any type of supply capable of furnishing 125 volts of bias.

Another application of the VR tube keying circuit is shown in *Fig. 6*. This arrangement makes it possible to key a buffer stage or the oscillator so that break-in keying may be utilized. Bias for the control tube is obtained automatically at the correct time from the grid resistor of the final amplifier. The protection the control tube gives to the final amplifier, if exci-

tation fails or when doubler and buffer stages are being adjusted, makes this keying system a valuable adjunct to a beam power or pentode final. (On higher-powered finals, a huskier beam power tube must be used as a control tube.)

One additional component has been added to the circuit by Bill Scherer, W2AEF. This addition is a 5-henry choke placed in series with the screen lead at the point marked "X". The choke was added to give a more rounded leading edge to the keyed character. Further details on this addition may be found in Scherer's article, "The Gold-Plated Special," in *CQ*, October, 1948.

For those who wish to design an amplifier operating under conditions other than those shown here, a detailed description of the system is given in "VR Tube Keying Circuits," which appeared in the May, 1948 issue of *CQ*. Another version of the system is described in "A TVI-Free Transmitter for 10 Meters" which was published in *CQ* for October and November, 1949.

If clickless keying is desired, the VR tube keying system is a straightforward answer to a problem that has been confronting hams since the days of the spark transmitter.

PARTS LIST

Fig. 5
$C_1 = 3.0$ uf, 150 working volts
$R_1 = 5800$ ohms, 2 watts
$R_2, R_1 = 0.25$ megohm, 0.5 watt
$R_3 = 10,000$ ohms, 50 watts
$R_5 = 50,000$ ohms, 0.25 watt
$R_6 = 100$ ohms, 0.5 watt
$R_7 = 0.1$ megohm, 0.5 watt

Fig. 6
$L = 0.5$ henry, grid choke
$R_1 = 1250$ ohms, 5 watts
$R_2 = 4400$ ohms, 20 watts
$R_3 = 0.1$ megohm, 0.5 watt
$R_4 = 1000$ ohms, 10 watts
$R_5, R_7 = 0.25$ megohm, 0.5 watt
$R_6 = 20,000$ ohms, 5 watts
$R_8 = 7500$ ohms, 5 watts
$R_9 = 0.5$ megohm, 0.5 watt
$R_{10} = 35,000$ ohms, 100 watts
$R_{11} = 50,000$ ohms, 5 watts
RF components and bypass capacitors are conventional.

TYPE DESIGNATIONS

The following dual type designations are being dropped in favor of single identification. As stocks of double-branded tubes are exhausted, single branded tubes will take their places. There is no change in tube characteristics or quality.

Old Brand	New Brand
1B3GT/8016	1B3GT
6AB7/1853	6AC7
6AC7/1852	6AB7

CODE-PRACTICE OSC

Continued from Page 1

The code oscillator is mounted on a wood board and is complete except for headphones. A 1½-volt radio "A" cell (RCA-VS036) serves to heat the 50-milliampere filament of the 1A5-GT, and a very small 45-volt "B" battery (RCA-VS055) is adequate to supply power to the plate of the tube, which draws only ½ milliampere. The transformer and circuit were chosen to provide good volume for the phones at low battery drain.

The 1A5-GT is a pentode, connected as a triode (with screen tied to plate) in a Hartley-type oscillator circuit. When the transformer is mounted, washers or some other type spacers should be used to provide clearance between the base of the transformer and the baseboard for the transformer leads. The batteries are held with wires fastened to the baseboard by means of soldering lugs and wood-screws. The connections to the 1½-volt VS036 are soldered. A standard snap-type battery plug is used for the 45-volt VS055.

Pitch Control

No provision was made in this

model for changing the tone of the oscillator, but a pitch or frequency control can be added if desired. This control is a 100,000-ohm potentiometer (such as an ordinary volume control) which, in series with a 100,000-ohm fixed resistor, replaces the 180,000-ohm resistor. An on-off switch on the pitch control may replace the knife switch (S).

With this code practice oscillator, several headphones may be used in series, or an amplifier may be connected in place of the phones. The tone is very good, and is much more pleasing and realistic than that obtained with a buzzer.

PARTS LIST

$R_1 = 180,000$ ohms, 0.5 watt
$R_2 = 100,000$ ohms, 0.5 watt
$R_3 = $ Pitch control potentiometer, 100,000 ohms, 0.5 watt
$C_1, C_3 = 0.005$ uf, Sprague disc ceramic
$C_2 = 0.001$ uf, Sprague disc ceramic
S = SPST knife switch
T = Audio interstage transformer, push-pull plates to push-pull grids, Thordarson T20A24 or equivalent
A = "A" battery, 1½ volts, RCA-VS036
B = "B" battery, 45 volts, RCA-VS055
Socket = Panel-mounting type Eby 12-8 octal
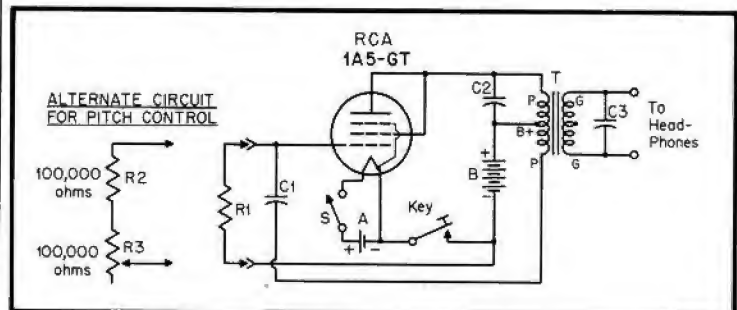
Wiring diagram of the code-practice oscillator.

Completed code-practice oscillator is simple and compact. (Those RCA Batteries last longer!)

SIMPLE OVER-MODULATION INDICATOR

By George Hanchett, W2YM
RCA Tube Dept., Harrison, N. J.

This simple and inexpensive over-modulation indicator is a useful piece of equipment which enables the amateur to comply with the FCC requirements for amplitude-modulated transmitters. It consists essentially of a high-voltage rectifier, type 1B3-GT, a 50-ohm potentiometer R, and a small neon glow lamp (NE45). A diagram of this indicator connected into a typical class C modulator stage is given in *Fig. 1*. Filament voltage for the 1B3-GT is obtained from the drop across the potentiometer R. This potentiometer is calibrated, as described below, in milliamperes of plate current so that when once the final has been adjusted, the proper filament voltage can be applied to the 1B3-GT. The 1B3-GT can be used with any transmitter in which the final plate current exceeds 225 milliamperes. Transmitters having a final plate current of less than 225 milliamperes may use a tube such as the 3V4 diode-connected (grid No. 1 tied to filament mid-tap; grid No. 2 tied to plate) provided the plate supply voltage does not exceed 600 volts.

When the amplitude of the modulation voltage drives the instantaneous plate voltage of the modulated amplifier to a value negative with respect to B— the rectifier conducts allowing the neon lamp to glow and, thus, to indicate over modulation.

Adjustment and Use

When the transmitter is being adjusted, potentiometer R should *always* be set so that there is no

UP TO 3000 MC!

Another "RCA First" in advanced tube design . . . the RCA-5675 "Pencil Type" triode for UHF applications is typical of RCA engineering leadership in developing new and better tubes for communcations and industry. The Fountainhead of Modern Tube Development is RCA.

Figure 2

$$\frac{\% \text{ modulation}}{100} = \frac{\text{Total bleeder voltage} - \text{tap voltage} + \text{glow lamp voltage}}{\text{total bleeder voltage}}$$

Figure 3

voltage on the filament of the 1B3-GT. This precaution is necessary to prevent damaging the tube. After the transmitter adjustments are completed, the plate current of the modulator stage is measured and the potentiometer R set accordingly. In the circuit shown in *Fig. 1*, the neon lamp will glow when the rectified voltage is approximately 75 volts. If indication of 100-per-cent modulation is desired, the bleeder tap should be set at 75 volts. If it is desired that modulation percentages of less than 100 per cent be indicated, the following equation should be used for calculating the position of the voltage tap on the bleeder. (See Figure 3)

Calibrating Potentiometer R

Potentionmeter R may be calibrated, as shown in *Fig. 2*, by means of a 6-volt battery, a 25-ohm (25-watt) variable resistor Rs, and a meter. Adjust the variable resistor Rs to provide a definite value of current, say 300 milliamperes on meter A, and then adjust potentiometer R so that the voltage applied to the filament of the 1B3-GT is 1.25 volts. Because there is slight interaction resulting from the position of the variable arm of R, a few further adjustments of Rs and R may be necessary to obtain correct voltage and current readings. Rs is then set for different values of current and R is again adjusted to obtain the proper filament voltage. After sufficient readings are taken, a curve of final plate current versus dial reading for correct filament voltage may be plotted for future reference.

Figure 1

Getting Out OK!